

**TEKTRONIX®**

**4661  
DIGITAL X-Y PLOTTER  
SERVICE**

**INSTRUCTION MANUAL**

Tektronix, Inc.  
P.O. Box 500  
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070-1828-00

Serial Number \_\_\_\_\_

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## WARRANTY

All TEKTRONIX products are warranted against defective materials and workmanship for one year. Additionally, TEKTRONIX Computer Terminals, Calculators and related peripheral equipment are fully warranted against any trouble for the first 90 days. Any equipment trouble occurring to those TEKTRONIX products during the 90 day period will be repaired by TEKTRONIX personnel at no charge. Questions regarding this warranty should be discussed with your TEKTRONIX sales representative.

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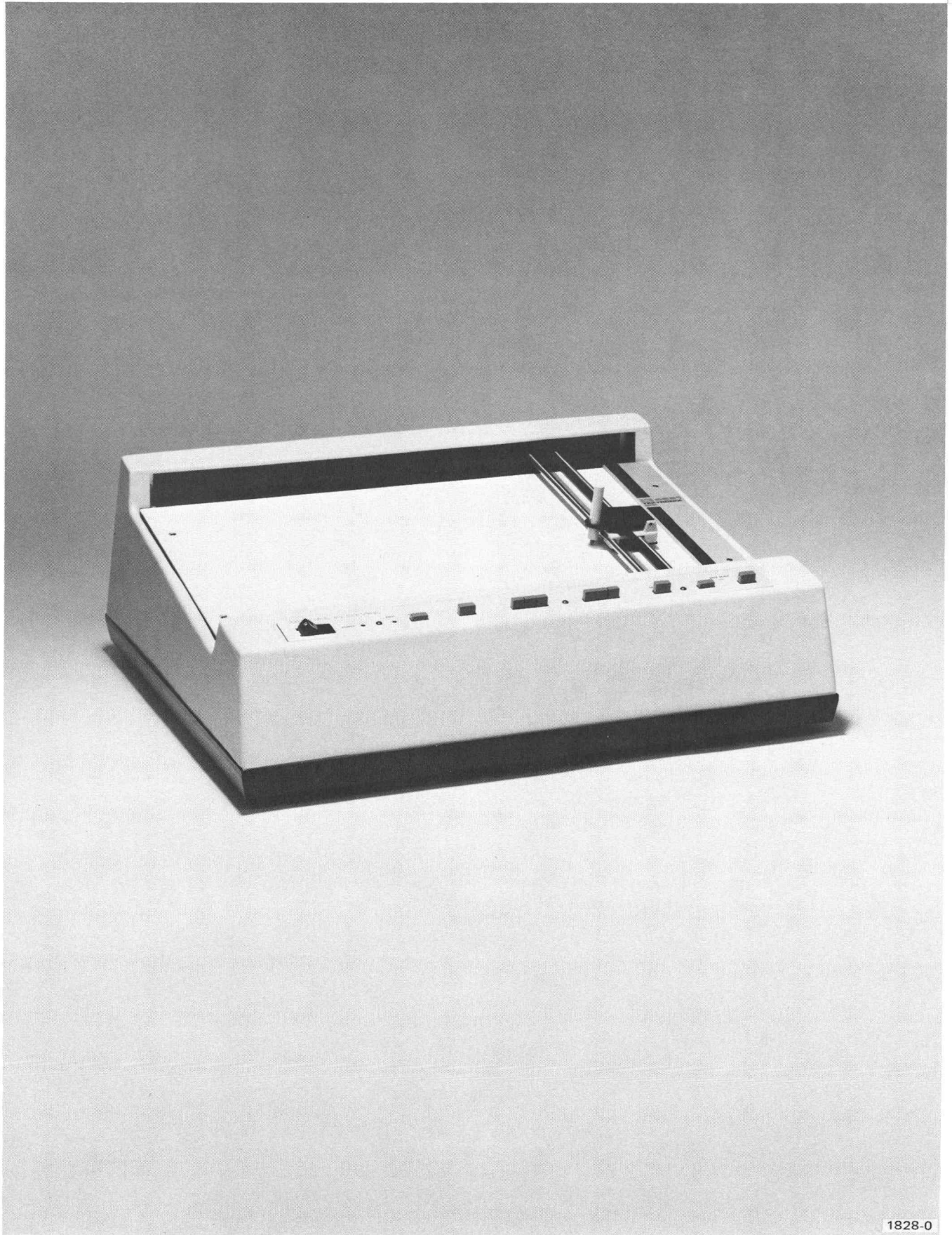
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1828-0

Fig. 1-1. 4661 Digital X-Y Plotter.

# Section 1

## INSTALLATION AND OPERATION

This manual is a part of the following set of documents that pertain to a Tektronix calculator system utilizing the 4661 Digital X-Y Plotter.

4661 DIGITAL X-Y PLOTTER OPERATORS MANUAL, Tektronix Part No. 070-1804-00.

Contents—An explanation of how to operate and care for the Plotter.

4661 DIGITAL X-Y PLOTTER SERVICE MANUAL, Tektronix Part No. 070-1828-00.

Contents—A comprehensive explanation of the Plotter. It includes operation, characteristics, servicing, adjustment, troubleshooting, circuit descriptions, and parts lists.

21 AND 31 CALCULATOR INTERFACING INFORMATION, Tektronix Part No. 070-1695-00.

Contents—A comprehensive explanation of the calculator interface.

21 OPERATORS MANUAL, Tektronix Part No. 070-1574-00.

Contents—An explanation on how to operate and program the TEKTRONIX 21 Calculator.

31 OPERATORS MANUAL. Tektronix Part No. 070-1575-00.

Contents—An explanation on how to operate and program the TEKTRONIX 31 Calculator.

### INTRODUCTION

The Tektronix 4661 Digital X-Y Plotter (Fig. 1-1) is a digitally stepped plotter that interfaces with either the TEKTRONIX 21 or 31 Calculator to provide graphic display of calculator computations. The information being plotted uses a vector format in which the pen moves in a straight line from one position to the next. Each position is defined by X axis and Y axis data entry expressed in inches. Pen movement is initiated upon the receipt of Y axis data. Commands are also available to lift and lower the pen, and to establish a new origin or plotting reference. Data entry in each axis may be an absolute position that references the origin or zero position, or a relative position that references the last pen position. Commands may be entered in any sequence except that X data must be entered prior to Y data.

Paper of any type is held in place on the platen by electrostatic attraction. Writing is done with a nylon-tipped pen. Each axis of the plotter is driven by a 4-phase stepping motor, which moves the pen bug on the X and Y axis shafts by means of plastic-covered cables. Each motor step results in a .005 inch of linear motion.

### INSTALLATION

Installing the plotter consists of making the plotter compatible with the available line voltage (modifying the plotter if necessary), connecting the plotter to the power source, and installing the interconnecting cable to receive signals from the calculator. The plotter is factory-wired for 110 V ac operation. Use either the standard interconnecting cable (supplied with the plotter) or one of the optional interconnecting cables for connecting the plotter to the calculator.

#### Installation Procedure

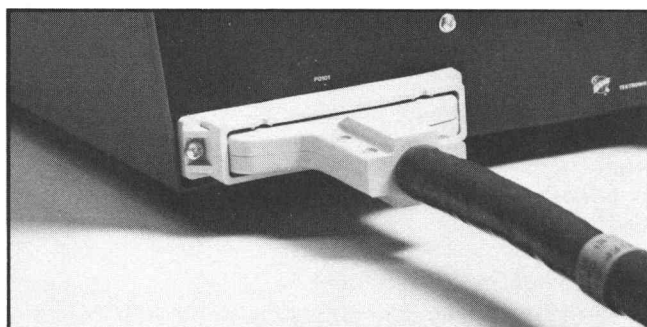
1. Check to see that the plotter is wired to accept the available power. The plotter is factory-wired to accept 110 V ac; however, other line voltage ranges may be selected. See Table 1-1. To change the plotter circuitry for operation at other voltages, the platen must be removed, the appropriate jumper must be changed, and the proper fuse must be installed. After reassembly, the platen must be aligned.

**TABLE 1-1**  
**Operating Voltages**

(Frequency range is 48 to 66 Hz, throughout)

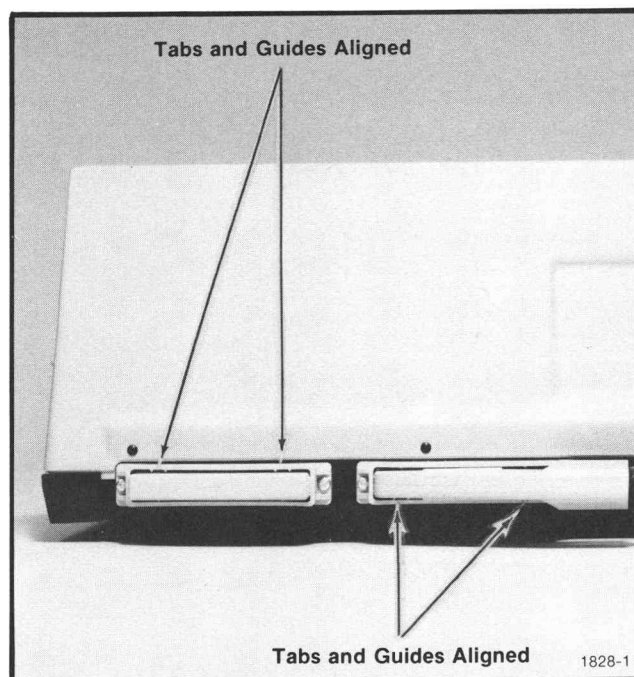
Voltage	Tolerance	Range	Fuse
100 V ac	±10%	90-110 V ac	2 A
110 V ac		99-121 V ac	
120 V ac		108-132 V ac	
200 V ac	±10%	180-220 V ac	1 A
220 V ac		198-242 V ac	
240 V ac		216-250 V ac	

2. Install one end of the interconnecting cable into the Calculator Input/Output connector, taking care to align the tabs on the cable end with the slots on the connector guide (tabs facing upward). See Fig. 1-2.



**Fig. 1-2. Calculator peripheral connections.**

3. Connect the other end of the cable into either of the plotter connectors, again taking care to align the tabs on the cable with the slots in the connector guide. On the plotter, one guide has slots on the upper side and the other has slots on the lower side (Fig. 1-3).

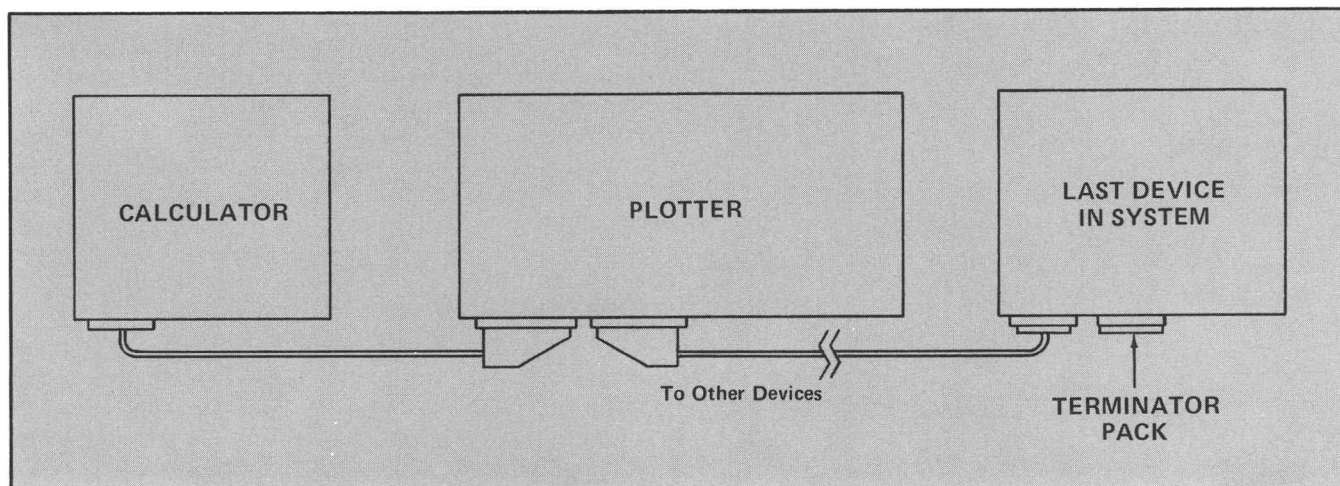


**Fig. 1-3. Plotter connections.**

4. Terminate the plotter's unused connector by installing the terminator pack (Figs. 1-3 and 1-4) unless calculator signals are being looped through the plotter to other devices in the system. If more than one device is being connected in a loop-through system, the terminator pack must be installed on the output of the device electronically farthest from the calculator.

**CAUTION**

*Plotters with serial numbers before B010265 require connection to an energized calculator before turning on the power. The serial number is located near the fuse holder on back of the instrument.*



**Fig. 1-4. Calculator system connection.**

## Platen Removal

1. Move the pen carriage to the right margin of the plotting surface.

### **WARNING**

*Hazardous voltages are exposed when the plotter case and/or platen are removed, unless the plotter is disconnected from the power source.*

2. Remove the four allen screws that attach the platen and the 4661 trim strip to the frame, keeping track of the location from which the screws are removed. See Fig. 1-5. The screws are of different lengths, and noting their position aids in reassembly. Remove the trim strip.

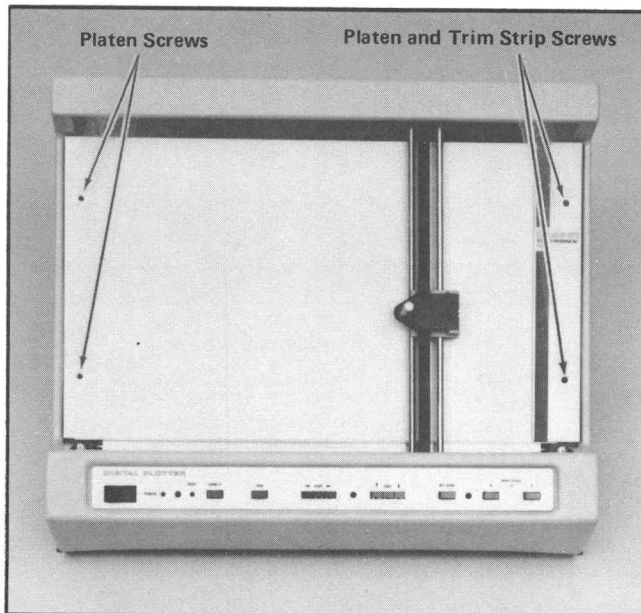


Fig. 1-5. Platen removal and alignment screws.

3. Lift the platen at the left bottom edge and slide the platen to the left until it clears the pen carriage, then lift slightly to expose the two wires that connect the platen to the High Voltage connector on the Power Regulator Board. Disconnect this harmonica plug from the connector pins, then remove the platen. Reverse the procedure to install the platen.

## Line Voltage Jumper

The line voltage jumper location is shown in Fig. 1-6. To change the operating voltage of the plotter, place either the 110 V ac connector or the 220 V ac connector (Fig. 1-7) on the appropriate jumper connection shown in Fig. 1-8.

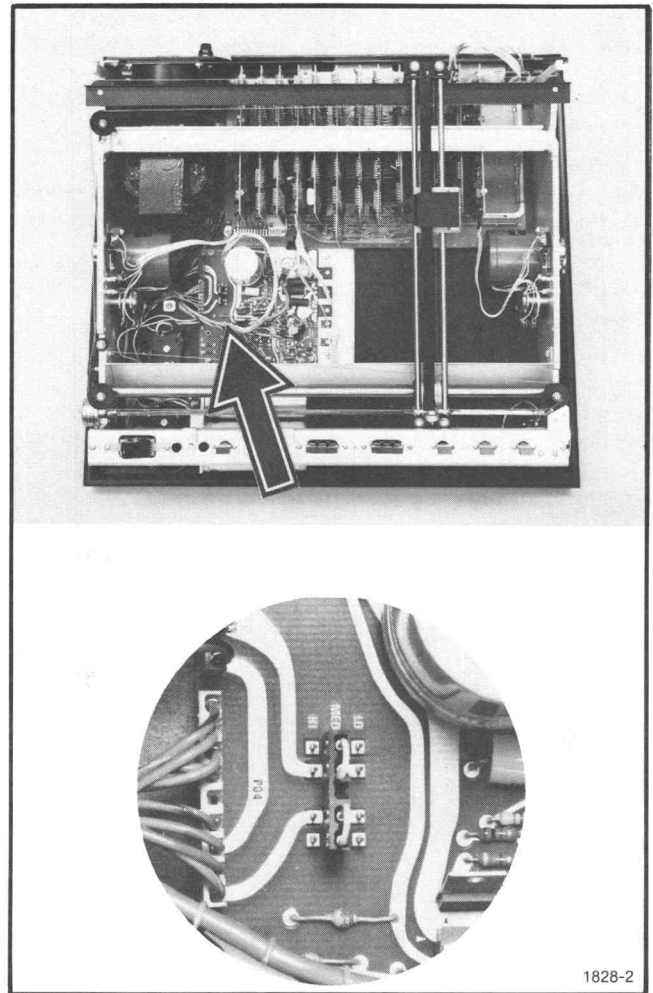


Fig. 1-6. Line voltage jumper location.

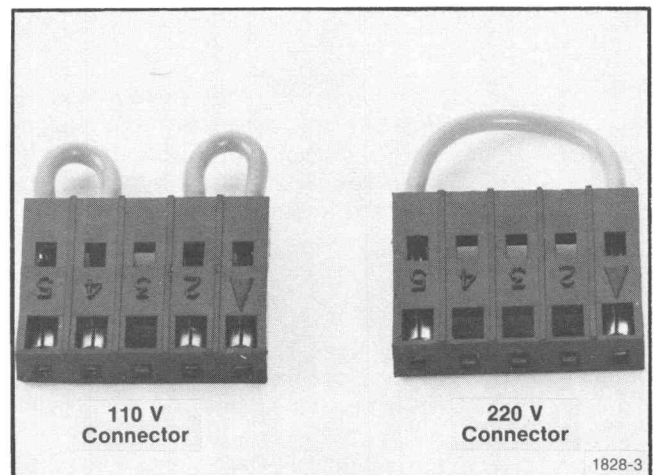


Fig. 1-7. 110 V ac and 220 V ac connectors.

## Installation and Operation—4661 Service

LO. ■ ■ ■ ■	100 VAC Range / (200 VAC Range)
MED. ■ ■ ■ ■	110 VAC Range / (220 VAC Range)
HI. ■ ■ ■ ■	120 VAC Range / (240 VAC Range)

Fig. 1-8. Line voltage connections. 200 to 250 volt range requires an alternate harmonica connector.

### Fuse

There is one fuse on the rear-panel of the 4661. See Fig. 1-9. To replace it, turn the fuse cap one-fourth turn counterclockwise and remove the cap. Install a new fuse in the fuse holder and replace the cap. Refer to Table 1-1 for proper fuse size.

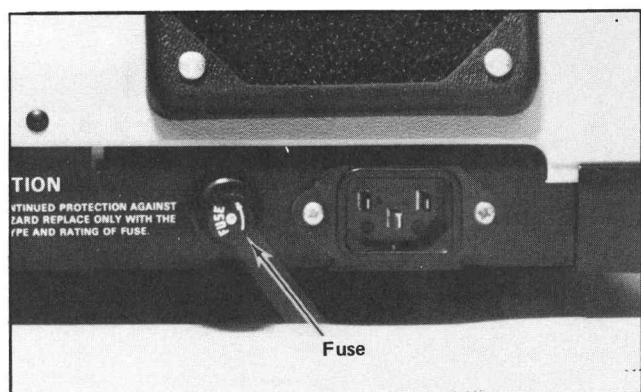


Fig. 1-9. Fuse location.

### Platen Alignment Procedure

Whenever the platen is removed, it must be aligned to ensure that lines drawn along the X axis will parallel the horizontal lines on the paper grid when the paper is positioned against the paper guide.

1. Connect the plotter to the power source. Instruments with serial numbers before B010265 must be connected to an energized calculator before turning on the power to the plotter. The serial number is located near the fuse holder on back of the instrument. Turn on the POWER switch.

2. Load the pen and paper. Press the LOAD button to lift the pen and move the pen carriage to the right margin. Manually lift the hinged flap of the pen carriage and insert the pen. Secure it by a one-fourth turn clockwise. Manually lower the flap. With the LOAD button depressed, place graph paper on the plotting surface. Carefully position the paper against the paper guide on the lower edge of the plotting surface. Release the LOAD button.

3. Press the PEN button to lower the pen to the graph paper.

4. Draw a horizontal line by pressing the pen positioning switches for fast manual move. See Fig. 1-10. Press the PEN switch to lift the pen. The line should be parallel to the grid lines on the graph paper.

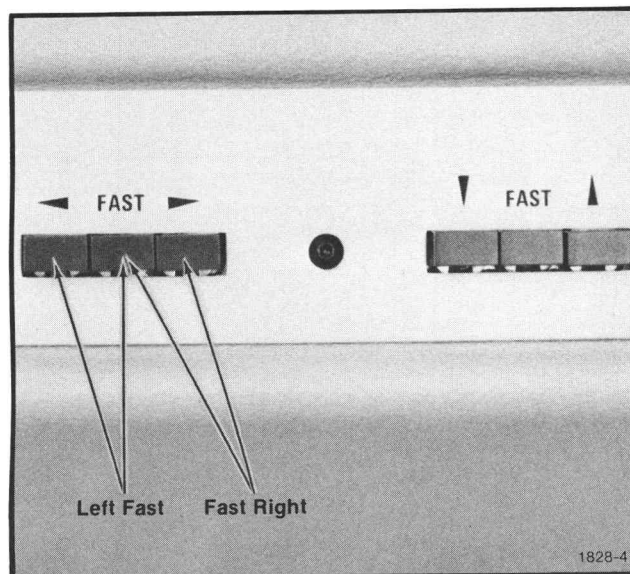


Fig. 1-10. Fast horizontal moves.

5. If necessary, loosen the four platen screws and adjust the platen. Repeat steps 3 to 5 for checking alignment.

### Changing the Plotter Address

The Plotter is connected at the factory to respond to a 3 in the tens digit of the Remote commands by a strap on the Calculator Interface #1 circuit card. This strap may be moved to allow the Plotter to respond to other values in the tens digit of the Remote instruction.

#### **WARNING**

*Hazardous voltages are exposed when the plotter case and/or platen are removed, unless the plotter is disconnected from the power source.*

Changing the plotter address involves removing the platen, the plotter case, the card retaining bar, and the Calculator Interface #1 circuit card. Use the following procedure:

1. Press the front panel LOAD button to move the pen carriage to the right hand margin. Turn the POWER switch off, and disconnect the power cord.

2. Remove the four allen screws that attach the platen and the 4661 trim strip to the frame, keeping track of the location from which the screws are removed. The screws are of different lengths, and noting their position aids in reassembly. Remove the trim strip.

3. Lift the platen at the left bottom edge and slide the platen to the left until it clears the pen carriage, then lift slightly to expose the two wires that connect the platen to the High Voltage connector on the Power Regulator card. Disconnect the two-pin harmonica plug from the connector pins, then remove the platen.

4. Remove the six screws that attach the plotter case to the frame. Three are located on the front panel, and three are located along the back of the case. Remove the case and the front panel.

5. Disconnect the two harmonica connectors from the rear edge of the Cal Interface #1 card. Remove the two screws that attach the card retainer strip to the frame, then remove the strip and the Cal Interface #1 card (Fig. 1-11).

6. Move the jumper to the appropriate location for the desired tens digit in the plotter address (Fig. 1-12).

7. Replace the circuit card in position on the Mother Board with the components facing left as the Plotter is viewed from the front.

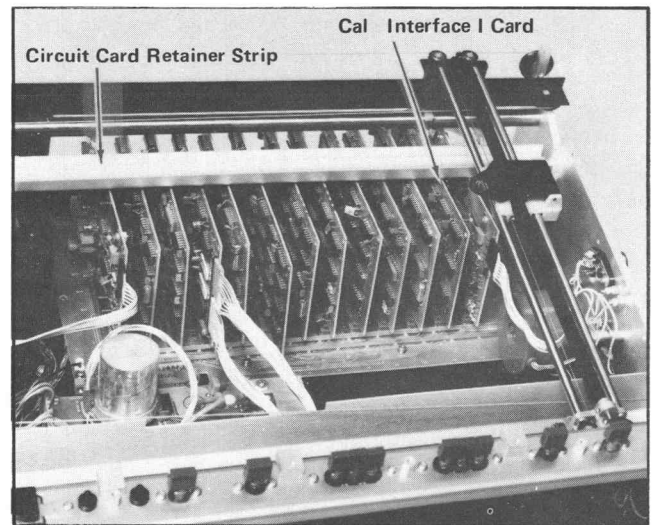


Fig. 1-11. Calculator Interface #1 Card and retainer strip locations.

8. Connect the two harmonica connectors to the pins on the rear edge of the Calculator Interface #1 card. The brown connector attaches to the set of pins labeled P1 and the red connector to P2. Pin 1 is at the top of each connector (Fig. 1-12).

9. Replace the circuit card retainer strip and install the attaching screws.

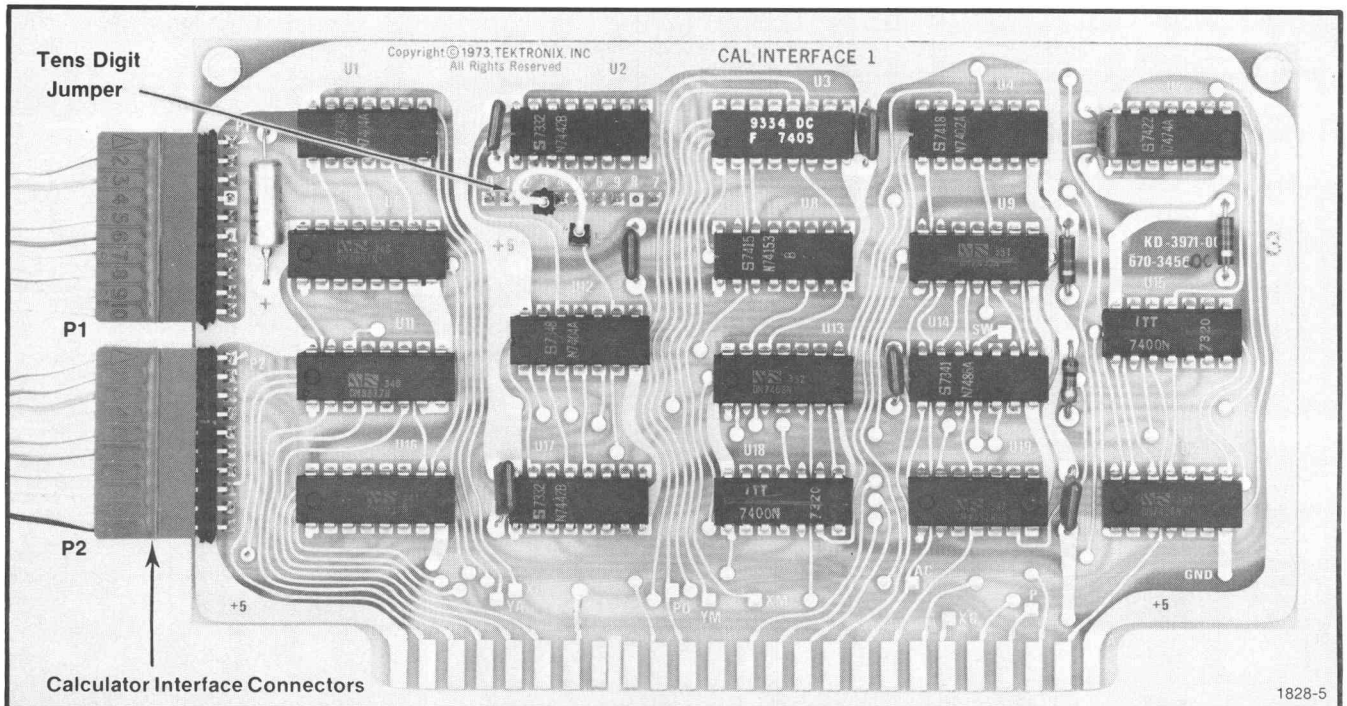


Fig. 1-12. Calculator Interface #1 connector locations.

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10. Replace the case on the frame and place the front panel in position on the case. Install the six attaching screws.

11. Connect the two-pin harmonica connector in place on the Power Regulator board, making certain that the wires will not interfere with the axis cables, then position the platen on the frame.

12. Place the trim strip in position at the right hand edge of the platen, and install the four attaching screws through the platen and trim strip. Align the platen, following the Platen Alignment Procedure, which appears previously in this section.

## OPERATION

This section outlines the basic plotter operations. The operations are classified as manual (for set-up purposes) and remote (for graphic display of calculator data).

### CAUTION

*Plotters before serial number B010265 require connection to an energized calculator before turning on the power.*

### Manual Operations

Manual operations utilize the plotter panel switches and pushbuttons.

**Initial Restart** When the POWER switch is turned on, the pen carriage moves to the right plotting boundary, then to the lower right corner, where it stops. The plotting origin is established near the lower left corner of the plotting boundary. See Fig. 1-13.

**LOAD** Pressing the LOAD switch deactivates the electrostatic paper hold-down, causes the pen to raise from the plotting surface, and causes the pen carriage to move to the right plotting boundary. The Plotter also goes off line and ignores all remote commands issued.

Releasing the LOAD switch activates the electrostatic paper hold, releases a plotter busy condition, and enables both the calculator and panel switches to control plotter circuitry.

**PEN** Pressing the PEN switch causes the pen to change state. If the pen was down, it will go up. If up, it will go down, except when the pen is at the plotting boundary as a result of a remote command. In this case the pen will remain up.

**Manual Move** Three pushbuttons control manual pen positioning for each axis. The outer buttons determine the direction and the center determines fast or slow. The center button affects the speed of both axes.

**SET ZERO** When pressed, it causes the plotter origin ( $X = 0$ ,  $Y = 0$ ) to become equal to the present pen location.

**HALF SCALE (X,Y)** The HALF SCALE pushbuttons, when pressed, cause data to be plotted to half of the issued value. Either or both switches may be in, causing half-scale plotting in the respective axes. Full-scale plotting of calculator data is in inches.

### Remote Operations

Remote operations involve communication over the Calculator Input/Output bus lines. The Plotter is wired at the factory to accept a 3 in the ten's digit of Remote commands. Instructions may be sent in any order except that X data must be sent before Y data.

The Remote commands as issued by the TEKTRONIX 21 and 31 Calculators perform the following functions:

**Remote 30** Set Zero. The plotter origin becomes the present pen location.

**Remote 31** X Absolute Data. Data being sent is to be plotted with respect to the plotter origin. No plotter movement takes place.

**Remote 32** Y Absolute Data. Data being sent is to be plotted with respect to the plotter origin. Plotter axis movement is initiated, plotting a vector.

Remote 33	Pen Down. The pen is caused to lower to the plotting surface unless the pen is at the plotting boundary as the result of a Remote command.	Remote 36	Y Relative Data. Data being sent is to be plotted with respect to the present pen position. Plotter axis movement is initiated, plotting a vector.
Remote 34	Pen Up. The pen is caused to lift from the plotting surface.		
Remote 35	X Relative Data. Data being sent is to be plotted with respect to the present pen position. No plotter movement takes place.	Remote 37, 38, and 39	Are not used and do not affect the mechanical operation of the plotter.

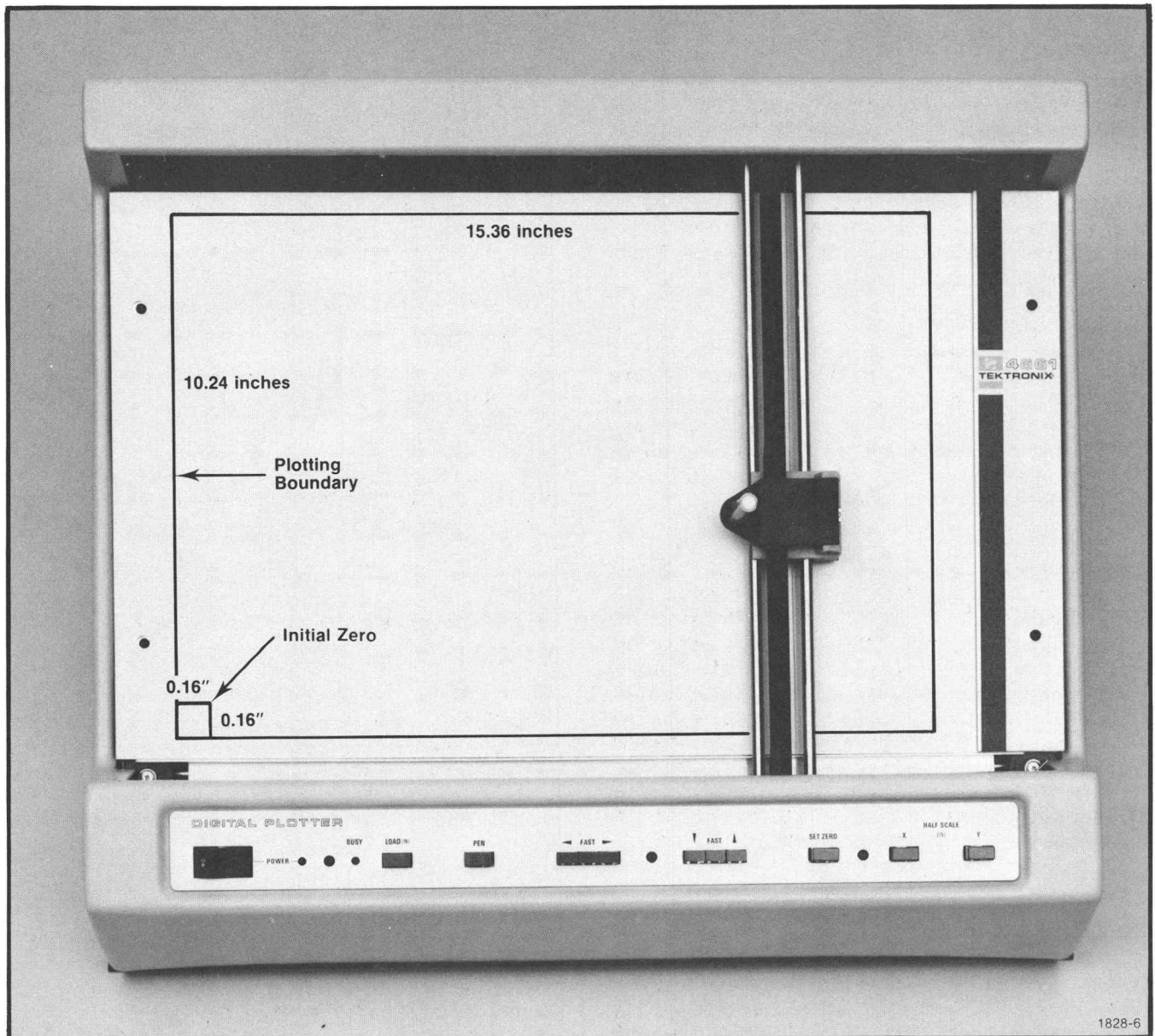


Fig. 1-13. Offscale Plotting Boundary and Initial Zero.

## PLOTTER CHECKOUT PROCEDURES

The Plotter Checkout section of this manual is intended to verify that the Plotter is operating properly. Manually controlled and remotely controlled performance checks are handled separately.

### Manual Performance Check

If the 4661 Plotter has a serial number before B010265 the plotter should be connected to an energized calculator before the power is turned on. If any of the manual performance checks fail, the problem may be in the Panel Interface or any of its associated circuitry.

1. Turn on the power to the 4661 Plotter. The pen carriage should move to the right plotting margin and down to the lower right corner. If there is failure to start movement, the restart logic on the power supply may be at fault. If the motors grind after reaching the plotting boundary, the Panel Interface limit switches may be at fault. If the motors grind and go nowhere, the instrument may need lubrication, or the Step Drive circuits or Velocity Compensator may be at fault. In any malfunction regarding initial restart, refer to the Initial Program of the Plotter Control circuitry.

2. The PEN pushbutton changes the state of the pen. If the pen fails to change state, perform a manual axis move and try again. If the pen fails to lower or lift, the hinge of the pen holder may be damaged, the connections to the pen solenoid may be disconnected from the power supply; or there may be faulty circuitry in the power supply, on the Program card, and on the Panel Interface card.

3. The manual axis positioning controls use two groups of three pushbuttons, one group per axis. The outer buttons determine axis direction. Pressing one causes slow pen movement (0.061 inch per second, or ips) in the direction indicated by the arrows on the front panel. Pressing both outer switches in each group cancels movement in that axis. Pressing the center switch in conjunction with an outer switch causes fast manual movement (3.91 ips) in the indicated direction. If the 4661 Plotter fails to perform the manual moves, the fault may lie in the stepping motor connections, the Step Drive circuits, the Velocity Generation circuits, or the Axis Control.

4. Checking the SET ZERO switch and HALF SCALE switches requires the use of the calculator. Pressing the SET ZERO switch establishes the plotter zero at the present pen position. Entering via the calculator (Clear Display, Remote 31, Remote 32) causes the pen to move to the established zero or plotter origin position. The HALF SCALE switches cause plotting to half scale. Data entered is relative to inches of pen movement or position when

plotting to full scale. The HALF SCALE switches are used during the Remote Performance Check program.

### Remote Performance Check

The Remote Performance Check exercises all the remote commands. All the plotter circuitry, not exercised by the Manual Performance Check, is exercised using the calculator program of Fig. 1-14 written for the TEKTRONIX 21 and 31 Calculators. The results of the program with dimensions thereon are illustrated in Fig. 1-15. The following procedure is to be used.

1. Turn the plotter off, then on to establish the plotter zero reference in the lower left corner. The pen moves to the lower right corner.

2. Load the program (Fig. 1-14) into the calculator, which is connected to the plotter.

3. Prepare the plotter for full-scale plotting. A pen should be inserted in the pen carriage and the HALF SCALE switches should be up.

4. Load a lightweight paper (*ie.* plotter chart paper) into the plotter.

5. Release the LOAD switch.

6. Start the calculator program. Converging lines with the vortex at the plotter origin are drawn (Fig. 1-15). Remote commands 31, 32, 33 and 34 are exercised.

7. When the checkout program stops, set the Plotter for half-scale plotting by pressing in both HALF SCALE switches.

8. Continue the checkout program. Parallel lines are drawn, with an increasing number of increments per line as the lines get shorter. Wavy lines indicate a loose drive cable. All the Remote commands are exercised. All the critical Plotter circuits are also exercised.

9. Remove the paper from the plotter and overlay it on the full-size checkout diagram, Fig. 7-1, in the charts and schematics section. If the checkout diagram (Fig. 7-1) and the plot you obtained do not agree, the checkout program (Fig. 1-14) may not have been properly entered into the calculator, or the plotter may be malfunctioning. First check your calculator program entry, reset the plotter zero position to the lower left corner, and repeat the checkout program.

## CHECK-OUT PROGRAM

00000	CLDP	00400	2	00900	.	01400	4
00001	=	00401	K_	00901	2	01401	CLDP
00002	K_	00402	1	01000	4	01402	1
00003	3	00403	RM_	01001	=	01403	=
00004	7	00404	3	01002	K_	01404	K_
00005	.	00405	1	01003	0	01405	3
00006	5	00406	K_	01004	CLDP	01406	K_
00007	=	00407	5	01005	.	01407	0
00008	K_	00408	RM_	01006	9	01408	/
00009	1	00409	3	01007	=	01409	2
00010	CLDP	00410	2	01008	K_	01410	=
00011	1	00411	K_	01009	4	01411	K_
00012	0	00412	3	01100	STOP	01412	0
00013	=	00413	+	01101	LBL_	01413	K_
00014	K_	00414	1	01102	HVP	01414	4
00015	4	00415	=	01103	CLDP	01415	*
00016	CLDP	00416	K_	01104	RM_	01416	1
00017	.	00417	3	01105	3	01417	.
00018	5	00418	-	01106	1	01418	5
00019	=	00419	5	01107	1	01419	=
00020	K_	00420	3	01108	=	01420	K_
00021	2	00421	RM_	01109	RM_	01421	4
00022	LBL_	00422	3	01200	3	01422	EXC_
00023	BRC	00423	4	01201	2	01423	HVP
00024	K_	00424	IF<0	01202	RM_	01424	CONT
00025	2	00425	EXC_	01203	3	01425	K_
00026	*	00426	BRC	01204	0	01426	3
00027	K_	00427	CONT	01205	RM_	01427	+
00028	3	00428	CLDP	01206	3	01428	1
00029	=	00429	2	01207	3	01429	=
00030	K_	00430	=	01208	LBL_	01430	K_
00031	5	00431	RM_	01209	TAN	01431	3
00032	RM_	00432	3	01300	K_	01432	-
00033	3	00433	1	01301	0	01433	3
00034	1	00434	CLDP	01302	RM_	01434	7
00035	K_	00435	1	01303	3	01435	3
00036	4	00436	=	01304	5	01436	IF=0
00037	RM_	00437	K_	01305	RM_	01437	RM_
00038	3	00438	3	01306	3	01438	3
00039	2	00439	=	01307	6	01439	4
00040	RM_	00440	RM_	01308	K_	01440	STOP
00041	3	00441	3	01309	4	01441	CONT
00042	3	00442	2	01400	-	01442	EXC_
00043	CLDP	00443	RM_	01401	K_	01443	TAN
00044	RM_	00444	3	01402	3		
00045	3	00445	0	01403	3		
00046	1	00446	CLDP	01404	IF<0		
00047	RM_	00447	1	01405	RM_		
00048	3	00448	0	01406	3		

Fig. 1-14. Remote Performance Check Program.

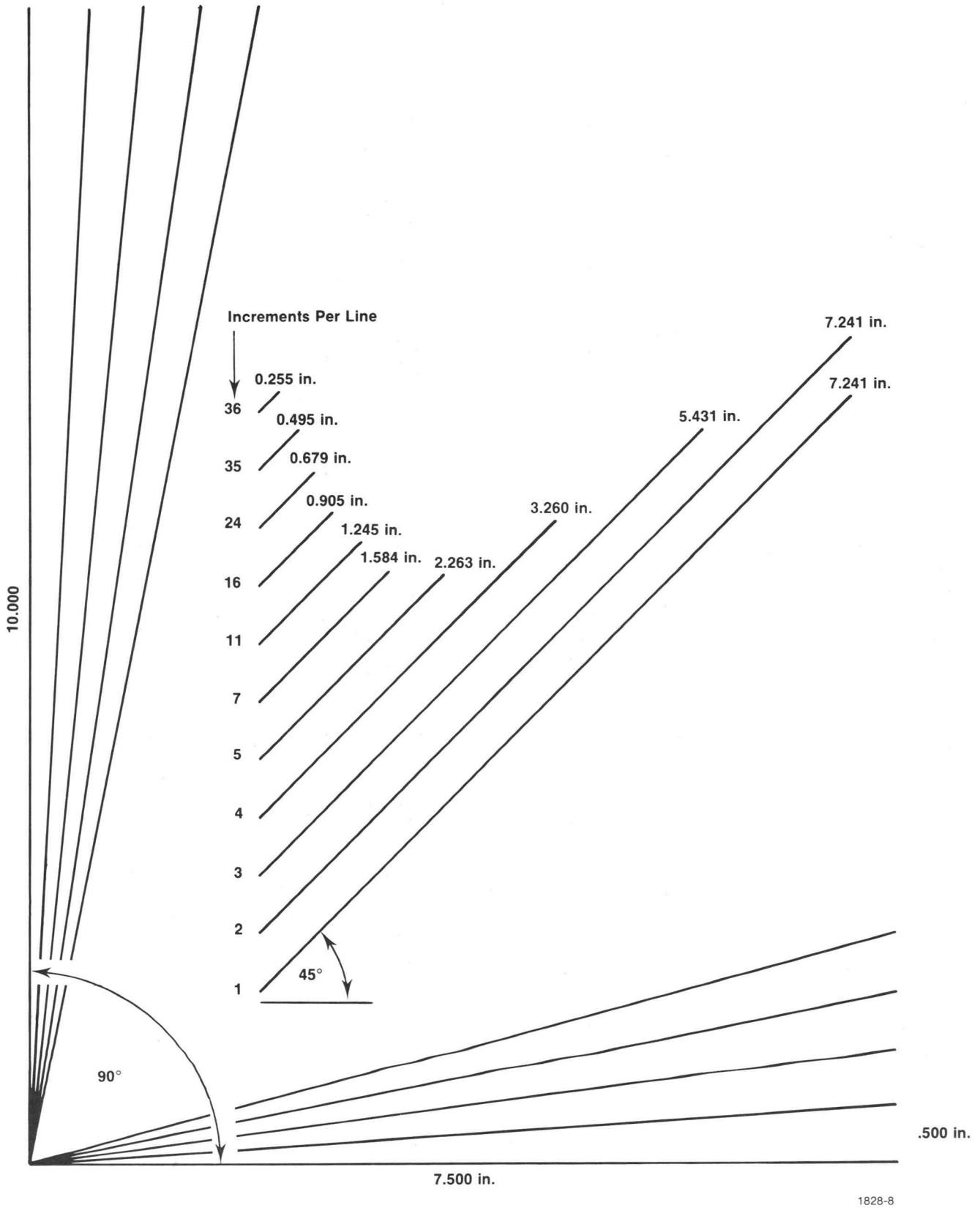


Fig. 1-15. Remote Performance Check Diagrams. (A full size checkout diagram may be found on a foldout.)

# Section 2

## CHARACTERISTICS

### General

This section details the performance limits and specifications applicable to the 4661 Digital X-Y Plotter. Plotter operation is covered in the operation section of this manual and in the 4661 User's Manual. Performance, physical, electrical, and environmental specifications are found in the following tables of this section.

At the end of this section are lists of accessories that are used with the plotter.

The following conditions must be met before all plotter characteristics can be considered valid:

1. The equipment must be operating in an environment specified by the Environmental Specifications.
2. Specified power requirements must be met.
3. The plotter must be properly lubricated.
4. The cables and pen assemblies must be properly adjusted. (The adjustments are set at the factory and should remain valid upon receipt of the instrument.)

### SPECIFICATIONS

The plotter recognizes a 3 in the tens digit of calculator remote commands as a valid device number. Other numbers can be accommodated by changing a strap on the Calculator Interface #1 card.

TABLE 2-1

#### REMOTE COMMANDS

Remote 30	Set Zero
Remote 31	X Absolute Data
Remote 32	Y Absolute Data and plot vector
Remote 33	Pen Down
Remote 34	Pen Up
Remote 35	X Relative Data
Remote 36	Y Relative Data and plot vector
Remote 37, 38, and 39 are not used.	

TABLE 2-2

#### PERFORMANCE SPECIFICATIONS

Plotting Area	See Fig. 2-1.
Offscale Plotting Boundary	10.24 inches by 15.36 inches
Initial Zero	0.16 inch in from left boundary 0.16 inch up from bottom boundary
Initial Pen Position	Lower right corner on the offscale plotting boundary
Vector Length	The plotter will draw vectors of any length in the plotting area within the offscale plotting boundary.
Scale Selection	HALF SCALE switches select full-scale mode when up and select half-scale mode when down. Half-scale mode is selectable by axis. Calculator data input of 5.00 is equivalent to 5.00 inches on the plotter surface in full-scale mode. Input data of 5.00 is equivalent to 2.50 inches in the half-scale mode.

**TABLE 2-2 (cont)**  
**PERFORMANCE SPECIFICATIONS**

Plotter Origin (Zero Reference)	The plotter origin may be established at any point on the plotting surface by moving the pen to the intended origin and pressing the SET ZERO panel switch or by entering the Remote 30 set zero command via the calculator.
Repeatability	The plotter will return to any previously plotted point with an accuracy of $\pm 0.0025$ inch.
Plotting Accuracy	$\pm 0.0025$ inch or $\pm 0.4\%$ of vector length
Data Resolution	
Full Scale	0.010 inch on either axis
Half Scale	0.005 inch on either axis
Motor Drive Resolution	0.005 inch increment, using a 200 step stepping motor
Vector Linearity	
Geometry	The mean vector line will not deviate more than .0007 inch, per inch of line length, from a straight line drawn between two points.
Line Aberrations	Short non-linearities of a vector line will not deviate more than $\pm .005$ inch from the mean vector line.
Plotting Rate	
Slow Manual Move	.016 inch per second
Fast Manual Move	3.91 inches per second
Acceleration/ Deceleration	.488 to 15.625 inches per second
Terminal Velocity	15.625 inches per second
Velocity Acceleration	Acceleration from initial velocity (.488 inch per second) to terminal velocity (15.625 inches per second) requires 1.05 ms. Distance traveled during acceleration is 1.125 inches. The velocity profile during acceleration and deceleration approximates a sinusoidal function.
Point Plotting Rate	Pen action rate is 10 points per second maximum. Plotting points per second decreases for an increasing distance between points.
Off Line	The plotter goes off line and ignores calculator commands during manual moves, the initial power-on cycle, and during paper load.

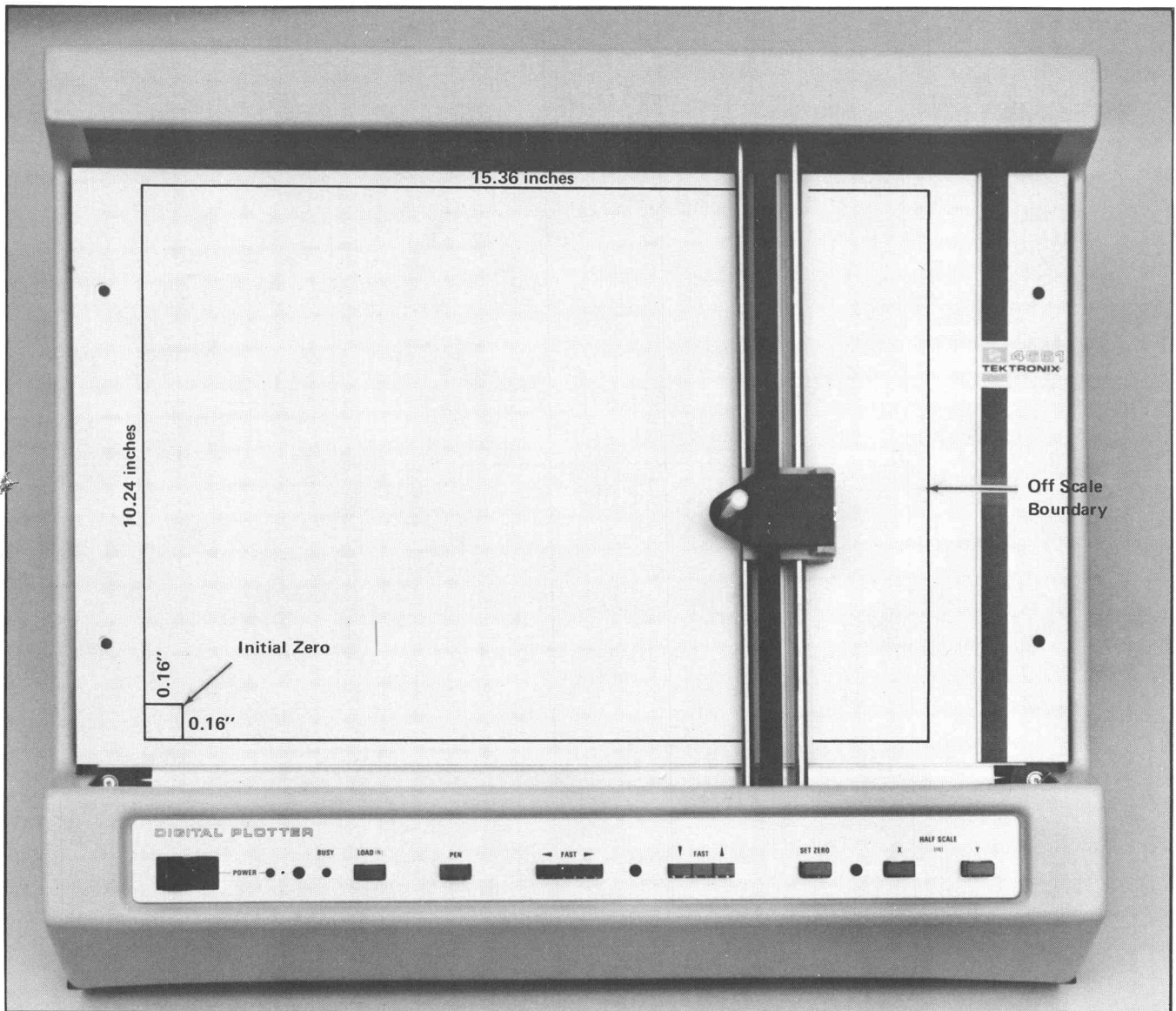


Fig. 2-1. Plotting Boundary and Initial Zero.

**TABLE 2-3**  
**PHYSICAL SPECIFICATIONS**

Dimensions	
Height	8 inches
Width	22 inches
Depth	18 inches
Weight	Approximately 40 lbs.
Writing Method	Nylon-tipped pen
Paper Size	Maximum paper size is 11 inches x 17 inches.
Paper Retainer	Electrostatic hold-down voltage on platen
Stepping Motor	200 steps per revolution resulting in an axis increment of 0.005 inch

**TABLE 2-4**  
**ELECTRICAL SPECIFICATIONS**

Power Consumption	180 watts maximum at 115 V ac and 60 Hz		
Line Voltage and Fuses	(48 to 66 Hz line frequency for all voltages)  100 V ac $\pm 10\%$ , 2 A fuse 110 V ac $\pm 10\%$ , 2 A fuse 120 V ac $\pm 10\%$ , 2 A fuse  200 V ac $\pm 10\%$ , 1 A fuse 220 V ac $\pm 10\%$ , 1 A fuse 240 V ac $\pm 10\%$ , 1 A fuse  Maximum line voltage is 250 V ac.		
Power Supply Ratings	<b>Voltage Supply</b>	<b>Regulation</b>	<b>Current Rating</b>
	+880 V dc	$\pm 15\%$	30 $\mu$ A
	+27 V dc	Unregulated	2 A
	+12 V dc	$\pm 7\%$	100 mA
	$\pm 5.1$ V dc	$\pm 2\%$	8 A
	-27 V dc	Unregulated	400 mA
Initial Restart ( $\overline{RST}$ )	Is active when the +5 V dc supply is out of range. $\overline{RST}$ remains low for 15 ms after the +5 V dc supply is established.		

**TABLE 2-5**  
**ENVIRONMENTAL SPECIFICATIONS**

Temperature	
Storage	−55°C to +75°C
Operating	0°C to +50°C
Humidity	
Storage	Up to 95%. If the plotter is exposed to relative humidity over 70%, recovery time of up to 24 hours is necessary for the electrostatic platen to be fully operational.
Operation	Up to 70%
Altitude	
Storage	to 50,000 feet
Operating	to 15,000 feet
Transportation	Qualified under National Safe Transit Committee test procedure 1A, Category II.

**TABLE 2-6**  
**STANDARD ACCESSORIES**

The following accessories are included as standard with the 4661.

1 Operators Manual	070-1804-00
1 Instruction Card	070-1749-00
1 Power Cord	161-0066-00
1 Calculator Interface Cable, (30 in., Type 1)	012-0498-00
1 Terminator Pack	016-0567-00
3 Pens, Black	016-0589-02
3 Pens, Red	016-0589-00
3 Pens, Green	016-0589-01
3 Pens, Blue	016-0589-03
1 Box 11 x 16-1/2 inch linear square chart paper, 10 divisions per inch, (100 sheets)	006-1698-00
1 Support Software Package	062-1672-00

**TABLE 2-7**  
**OPTIONAL ACCESSORIES**

The following optional accessories are available for the 4661.

Replacement pens (pack of 3)

Black	016-0589-02
Red	016-0589-00
Green	016-0589-01
Blue	016-0589-03

Paper

11 x 16-1/2 inch linear square chart paper, 10 x 10 to 1 inch, (100 per box)	006-1698-00
11 x 16-1/2 inch linear square chart paper, 10 x 10 to 1 cm, (100 per box)	006-1699-00
11 x 16-1/2 inch semi-logarithmic chart paper, 10 inch x 3 cycles (100 per box)	006-1700-00
11 x 16-1/2 inch semi-logarithmic chart paper, 15 inch x 2 cycles (100 per box)	006-1701-00
11 x 16-1/2 inch full logarithmic chart paper, 2 cycles x 3 cycles (100 per box)	006-1702-00

Calculator Interface Cables (See Fig. 2-2)

30 inch $\pm 10\%$ (Type 1)	012-0498-00
30 inch $\pm 10\%$ (Type 2)	012-0499-00
7 ft. $\pm 10\%$ (Type 1)	012-0498-01
7 ft. $\pm 10\%$ (Type 2)	012-0499-01

Extender Card Kit

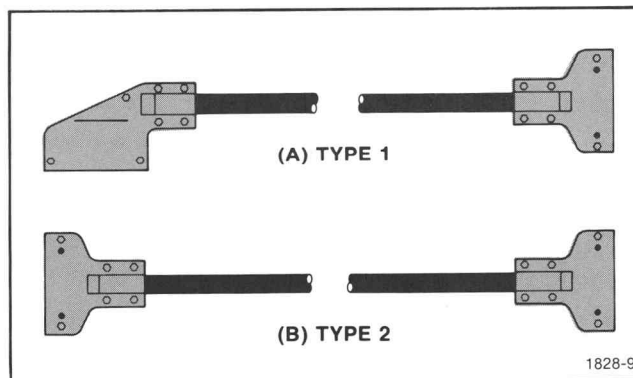
670-0743-00

Axis Drive Cables

X Axis Cable, 11 feet, size .034 in. diameter	214-2002-00
Y Axis Cable, 11 feet, size .018 in. diameter	214-2001-00

Manuals

4661 X-Y Plotter Operators Manual	070-1804-00
4661 X-Y Plotter Service Manual	070-1828-00
21 and 31 Calculator Interfacing Information	070-1695-00



**Fig. 2-2. Caluclator Interface Cables.**

# Section 3

## MAINTENANCE

### ROUTINE MAINTENANCE

Occasional cleaning will preserve the appearance of the 4661. In addition, cleaning the air filter on the cooling fan will improve air circulation and will also reduce the amount of dust and foreign particles entering the Plotter. This will, in turn, maximize the life of the components and reduce the frequency of required lubrication. The frequency of cleaning and lubrication will vary with the environment in which it is used, but annual maintenance is a recommended minimum.

#### CAUTION

*Plotters before serial number B010265 require connections to an energized calculator before turning on the power.*

### Cleaning the Plotter Platen and Case

The Plotter may be cleaned by using the following procedure:

1. Press the front panel LOAD button to move the pen to the right hand margin; then turn the POWER switch off and disconnect the power cord. Remove any paper present on the platen.

2. Use a cloth dampened in a mild detergent solution to wash the platen. Abrasive cleaners, such as scouring powder, must be avoided.

#### CAUTION

*Abrasive cleaners and strong chemical cleaners may scratch or even remove layers of the thin insulating film on the electrostatic platen.*

3. Remove moisture and soap residue from the platen with a clean, dry cloth.

4. The Plotter case may also be cleaned with a cloth dampened in the same mild detergent solution and dried as above.

5. Connect the power cord to the power source. The Plotter may again be operated normally.

### Cleaning the Air Filter

The cooling fan is provided to circulate air through the Plotter chassis to remove heat from the electrical components. When the filter becomes clogged with accumulated dirt, the fan cannot properly circulate air, and the air which is circulated is more likely to carry dirt which can contaminate the lubricant on the X-axis shafts. Therefore, the filter should be cleaned yearly at a minimum, and more often if necessary, using the following procedure:

1. Remove the four screws which attach the filter retainer to the Plotter case (Fig. 3-1).

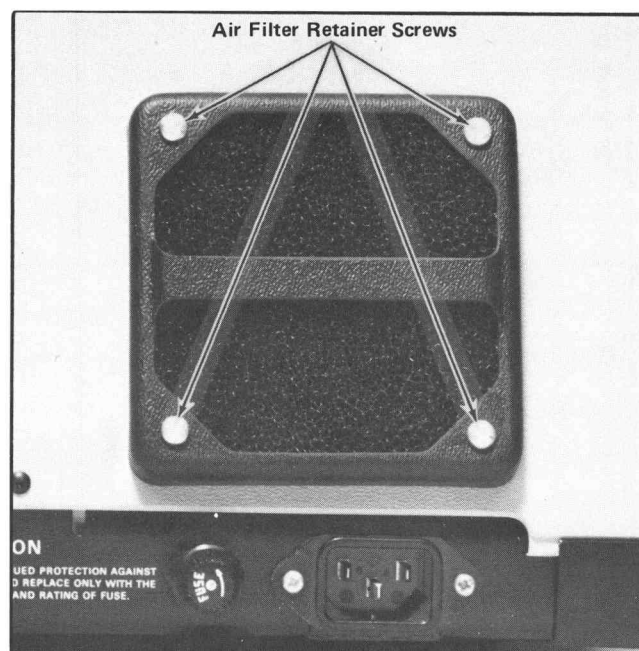


Fig. 3-1. Air filter retainer screws.

2. Remove the filter and clean it with a mild solution of liquid detergent; rinse it in clean water and dry it.

3. Replace the filter in the retainer; then secure the retainer to the Plotter frame with the four attaching screws.

### Lubrication Information

The bearings on which the axis cable pulleys turn are permanently lubricated and require no periodic lubrication. In addition, the Y-axis shafts are supported and stressed such that lubrication is not necessary. The polished surface of the shafts should, however, be kept free from soil. The X-axis shafts and the pen solenoid shaft within the Plotter should be lubricated at a minimum of once yearly, but more often when the lubricant on the shafts begins to dry and solidify, or when it becomes contaminated with dust and foreign particles. The procedure requires removing the platen and plotter case, lubricating three shafts in the plotter, reassembly, and platen alignment.

#### WARNING

*Hazardous voltages are exposed when the Plotter case or platen are removed, unless the Plotter is disconnected from the power source.*

### Removal of Platen and Plotter Case

#### CAUTION

*Plotters before serial number B010265 require connection to an energized calculator before turning on the power.*

1. Press the front panel LOAD button to move the pen carriage to the right hand margin. Turn the POWER switch off, and disconnect the power cord (Fig. 3-2).

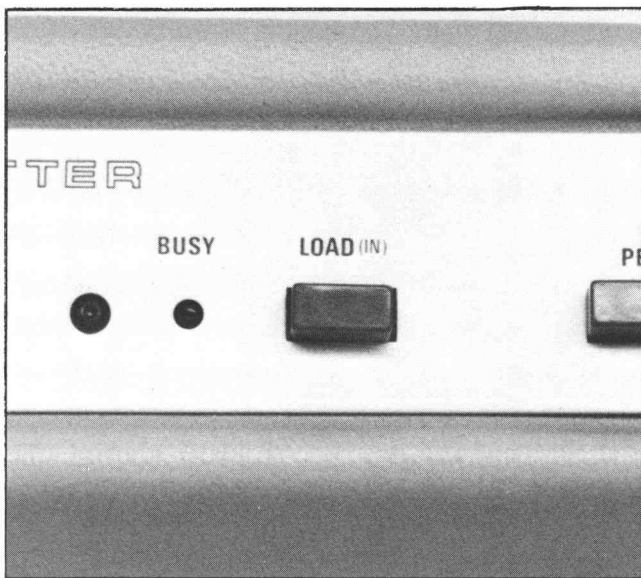


Fig. 3-2. LOAD button.

2. Remove the four allen screws that attach the platen and the 4661 trim strip to the frame, keeping track of the location from which the screws are removed (Fig. 3-3). The screws are of different lengths; noting their position will aid in reassembly. Remove the trim strip.

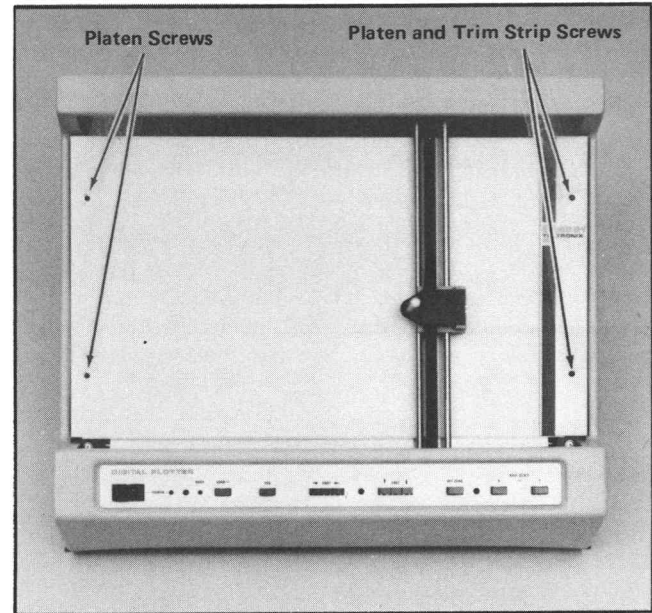


Fig. 3-3. Removing the trim strip.

3. Lift the platen at the left bottom edge, and slide the platen to the left until it clears the pen carriage, then lift slightly to expose the two wires which connect the platen to the High Voltage Connector on the Power Regulator board. Disconnect the two-pin harmonica connector from the connector pins, then remove the platen (Fig. 3-4).

4. Remove the six allen screws that attach the Plotter case to the frame. Three are located on the front panel, and three are located at the rear. Remove the case and the front panel (Figs. 3-5 and 3-7).

### Lubrication of Shafts

1. There are two X-axis shafts, along which the pen carriage moves horizontally; one runs along the front of the Plotter, and one along the rear. The pen solenoid shaft runs just in front of the forward axis shaft (Fig. 3-6). Clean the lubricant and contaminants from these shafts with paper tissue or cloth.

2. Lubricate the full length of the three shafts evenly with Lubriplate A, Type 105, or equivalent (Tektronix Part Number 006-0617-00). In addition, lubricate the two ends of the pen actuator bar (Fig. 3-6).

**CAUTION**

*Instruments before serial number B010265 require connection to an energized calculator before the power to the plotter is turned on.*

**Electrical Adjustment**

There is only one electrical adjustment within the Plotter. It is located on the Power Regulator Board and determines the voltage of the +5 V dc power supply (Fig. 3-4). When measuring the +5 V dc supply, make measurements between a circuit ground bus (not the chassis) and the +5 V dc bus. The voltage should be +5.1 V dc  $\pm 2\%$  (4.998-5.202).

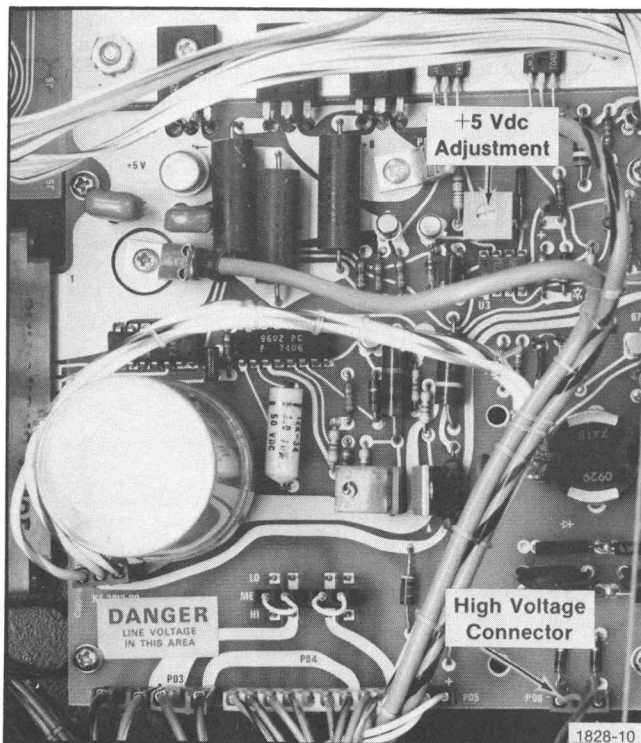


Fig. 3-4. High Voltage Connector and +5 Vdc Adjustment.

**Reassembly of Case and Platen**

1. Replace the case on the frame, and place the front panel in position on the case. Install the attaching screws (Figs. 3-5 and 3-7).

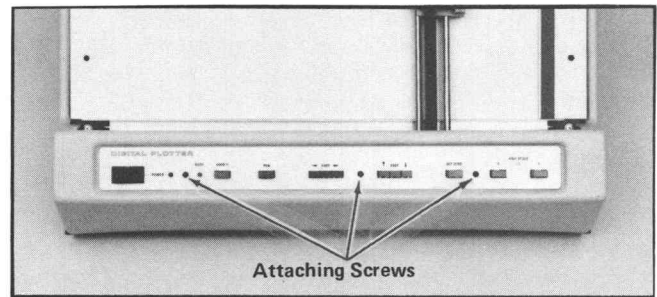


Fig. 3-5. Case and front panel attaching screws.

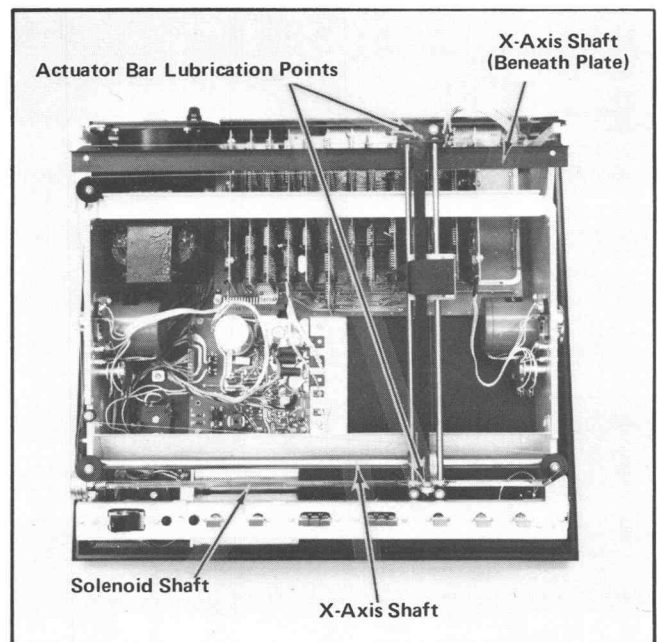


Fig. 3-6. X-Axis locations.

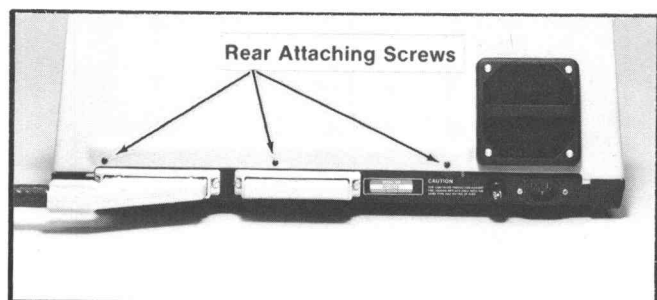


Fig. 3-7. Rear attaching screws.

## Maintenance—4661 Service

2. Connect the two-pin harmonica connector in place on the Power Regulator board, making certain that the wires will not interfere with the axis cables; then position the platen on the frame (Fig. 3-8).

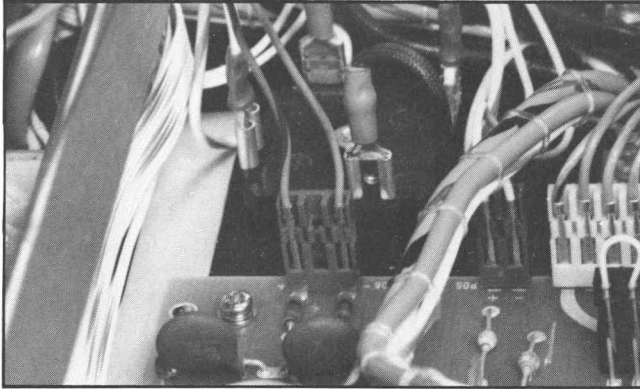


Fig. 3-8. Installing the High Voltage Connector.

3. Place the trim strip in position at the right-hand edge, and install the four attaching screws through the platen and trim strip (Fig. 3-9). Align the platen, following the Platen Alignment Procedure, which follows.

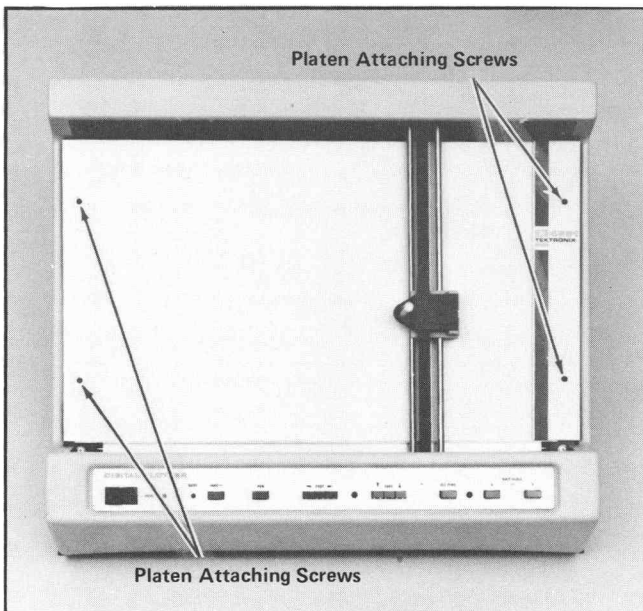


Fig. 3-9. Installing the platen and trim strip.

### Platen Alignment Procedure

Whenever the Platen is removed, it must be aligned to make certain that the platen and the paper guide are parallel to the X-axis shafts. This ensures that the lines drawn along the X-axis will parallel the horizontal lines on

the paper grid, when the paper is positioned against the paper guide. Use the following procedure:

1. Connect the Plotter to the power source, turn the POWER switch on, and load pen and paper in the Plotter. The left edge of the paper must be even with the left edge of the platen. The bottom edge of the paper must be against the paper guide. The paper must be positioned carefully to align the platen.

2. Release the LOAD switch and send the pen to the Zero location by clearing the Calculator display, then pressing Remote, 3, 1, Remote, 3, 2 keys, in that order. Press Remote, 3, and 3 to lower the pen.

3. Draw a straight line across the bottom edge of the paper by placing 15 in the Calculator display, then pressing the ) key, Remote, 3 and 1 keys. Then press the Clear Display key, ) key, and Remote, 3, and 2 keys. Press Remote, 3, and 4 to lift the pen after the move.

4. The line drawn across the paper should parallel the grid lines on the paper (Fig. 3-10). If not, loosen the four platen screws and adjust the platen position accordingly. Then repeat steps 2 and 3 to ensure platen orthogonality.

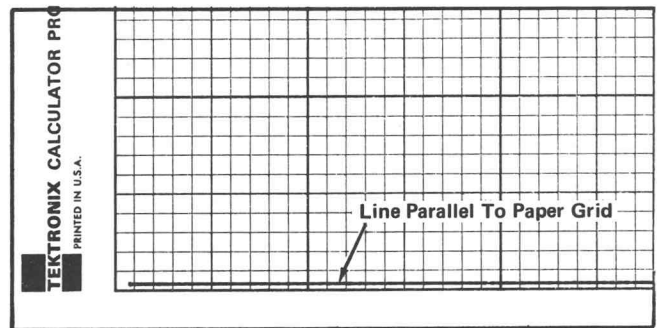


Fig. 3-10. Plotter line parallel to paper grid line.

## TROUBLESHOOTING INFORMATION

The following conditions must be met before all plotter characteristics can be considered valid.

1. The equipment must be operating in an environment specified by the Environmental Specifications.
2. Specified power requirements must be met.
3. The plotter must be properly lubricated.

**CAUTION**

*Plotters with serial number before B010265 require connection to an energized calculator before turning on the power.*

## Equipment

Equipment used to gain access to the plotter circuitry and perform the mechanical adjustments consists of the following:

Phillips screwdrivers.

#1 point, #2 point.

Allen wrenches.

7/64-inch, 3/32-inch, 1/16-inch, .050-inch.

Open end wrench, 1/4-inch.

Needle-nose pliers.

Wire cutters.

Spring tension gauge.

Accurate within  $\pm 1/4$  pound at 2-1/4 pound and at 5-1/4 pound.

Precision load meter (*ie.* phonograph stylus pressure gauge).

Range of 7 to 8 grams.

Feeler gauge.

.035 inch.

Axis Drive Cables.

X Axis Cable, 11 feet, size .034 inch diameter (Tektronix Part No. 214-2002-00).

Y Axis Cable, 11 feet, size .018 inch diameter (Tektronix Part No. 214-2001-00).

Equipment that is helpful in troubleshooting the plotter electronics consists of the following:

Extender Card Kit, Tektronix Part No. 067-3942-00.

Voltmeter for power supplies.

Ranges 10 V dc, 12 V dc, 40 V dc, and 1000 V dc.

Oscilloscope for logic.

10 MHz bandwidth, dual trace, delayed sweep.

16-pin integrated circuit test clip.

## Basic Troubleshooting Procedure

If the instrument does not operate according to specifications (see the checkout procedure of Section 1), the following procedure may locate or correct the cause of plotter malfunction.

1. Check the external electrical connections, the power cord and calculator interface cable(s).

2. Remove the platen and case.

3. Check the internal electrical connections. These connections are the pen solenoid connections, and circuit board connections on the Mother Board, Power Supply Board, Panel Switch Board, I/O Board, Calculator Interface #1, Panel Interface, and Step Drive cards.

4. Check the pen carriage cables. They should not be frayed or broken. They should be properly seated in the grooves of the pulleys.

5. There should be no binding in the pen carriage mechanism as it is moved along the X and Y axes. With the power off, the stepping motors give a gritty feel (motor cogging) as the pen carriage is manually moved. A force of less than one pound is all that should be necessary to move the pen carriage. Replace pulleys and cables if necessary and perform the appropriate mechanical adjustments.

6. Check the power supply voltages. Plotters with serial numbers before B010265 require connection to an energized calculator before turning on the power.

## Maintenance—4661 Service

7. The most common causes of plotter malfunction, other than loose or dirty electrical connections, are mechanical problems. Indications of mechanical difficulty include the inability to keep a position reference. This can be checked by using a calculator to enter commands that send the plotter pen carriage to the zero position. Lower and lift the pen to mark a point. Enter commands to send the pen carriage to several locations on the plotting surface, then back to the zero position. Lower and lift the pen to see if the pen drops to the plotting paper at the same place as before. Problems causing the plotter to lose position are as follows: (1) Lubrication may be needed on the X axis shafts. (2) If new cables have been recently installed, the cables may be too tight, causing the pen carriage to bind. (3) Bad bearings in the pulleys could be a problem, causing the carriage to bind and the motors to lose position. (4) The voltage circuitry for velocity compensation could be bad.

### Troubleshooting the Electronics

If the basic troubleshooting procedure does not identify a mechanical problem, the following information may be helpful in locating malfunctions in the electronics.

A recommended procedure is to replace circuit cards until the faulty card is found. The system description section of this manual describes the electronics in detail along with additional troubleshooting information. It is designed as an aid for an electronic technician to understand the plotter electronics and assist him in troubleshooting the circuitry.

## MECHANICAL ADJUSTMENTS

### Wire Stringing Instructions

Each axis of the Plotter is driven by a stepping motor that transmits motion to the pen carriage through plastic-coated wire cables, which run on a network of pulleys. If the cable breaks, if the cable coating should become worn or cracked, or if it is necessary to remove the cable during a mechanical disassembly procedure, it will be necessary to install new cables using the following procedure.

**Equipment Needed.** The following equipment is needed to remove the platen, string the cables, and realign the pen carriage.

#### Axis Drive Cables:

X Axis Cables, 11 feet, size .034 inch diameter (Tektronix Part No. 214-2002-00).

Y Axis Cable, 11 feet, size .018 inch diameter (Tektronix Part No. 214-2001-00).

#### Allen Wrenches:

1/16-inch, 3/16-inch, 7/64-inch, and .050 inch.

#### Tweezers or needle-nose pliers.

#### Wire cutter.

#### Phillips screwdrivers.

#1 point and #2 point.

#### Spring Tension Gauge.

Accurate within  $\pm 1/4$  pound at 2-1/4 and 5-1/4 pounds.

#### Ruled Plotter Paper, for realignment.

1. The platen and plotter case should first be removed, then the panel switch bar should be disconnected to obtain access to the axis drive cables. See Fig. 3-11. Refer to the procedure for removal of platen and plotter case previously mentioned in this section. To remove the panel switch bar, remove two screws—one from each end of the assembly. The panel switch assembly can then be folded down and out of the way. Do not remove the thin metal strip attached to the two rear pulleys.

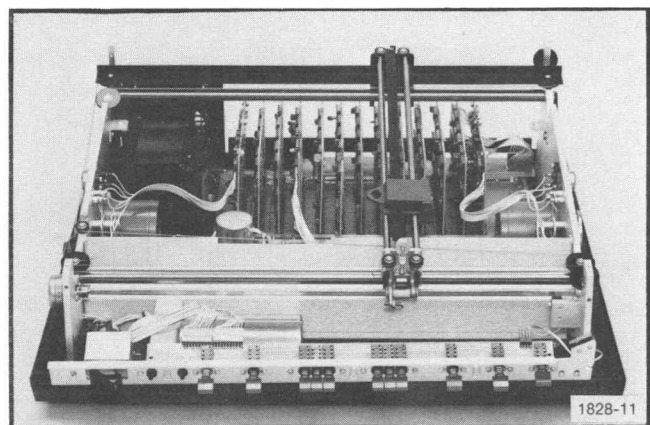


Fig. 3-11. Plotter setup for cable stringing.

2. Fasten the X axis and Y axis drive pulleys to the stepping motor drive shafts as illustrated in Fig. 3-12. The X axis drive pulley (the smaller of the two), is mounted on the left stepping motor with the inner pulley flange flush with the line extending along the outer surface of the plotter chassis. The Y axis drive pulley (the larger of the two), is mounted on the right stepping motor in the same manner.

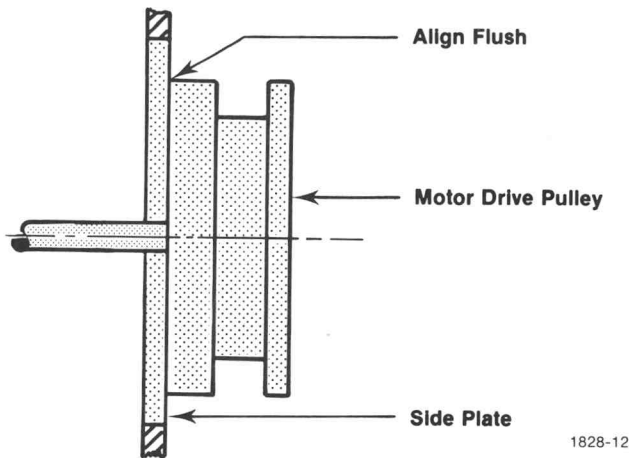


Fig. 3-12. Motor pulley position.

## NOTE

Use caution when feeding the drive cables through the drive pulleys to prevent snagging the plastic cable coating.

3. Start with the X axis drive pulley on the left side of the Plotter, and approximately 11 feet of the larger diameter wire (.034 inch diameter Tektronix Part No. 214-2002-00). The pen carriage should be manually moved to the right-hand edge of the platen. With the X axis drive pulley holes to the top-forward position (a 45° angle to the top and right of the drive shaft), thread about three feet of the .034-inch diameter cable through the forward hole from inside the drive pulley. Thread the remainder of the cable through the other hole. See Fig. 3-13.

4. While holding the X axis drive pulley in position, loop the shorter end of the cable (from the forward hole) clockwise under the drive pulley and across the top.

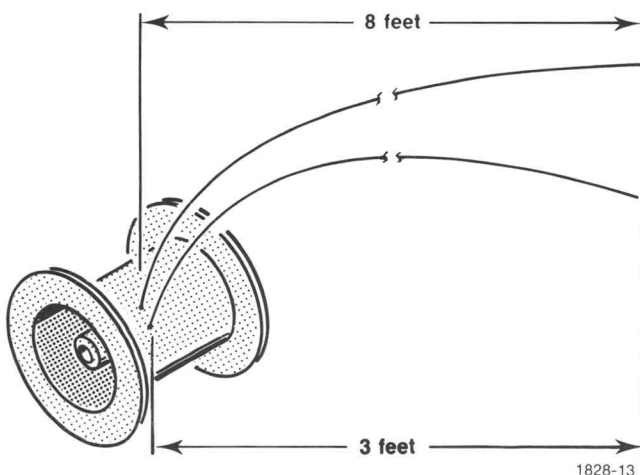


Fig. 3-13. X-Axis cable threading.

5. Refer to Fig. 3-14. Feed the same cable, from step 3, over pulley A, around the forward edge of pulley B, and fasten the cable with the securing screw on the left-front side of the pen carriage; leave no slack and do not allow the X axis drive pulley to rotate from its initial position established in step 2. Check to be sure the drive cable lies in the grooves of the appropriate pulleys.

6. Wind the cable onto the drive pulley by turning the pulley (not the cable) counterclockwise until the pen carriage moves to the stop at the left-hand edge of the platen. The cable windings should lie smooth toward the motor edge of the drive pulley.

7. Loop the long end of the drive cable counterclockwise over the top of the X axis drive pulley. Refer to Fig. 3-15. Feed the remainder of the cable clockwise across the back of pulley C, across the rear of the Plotter under the guard plate, counterclockwise around pulley D, across the rear of the Plotter, around the back of pulley E, around the front of pulley F, across the front of the plotter, and clockwise around pulley G. Fasten the cable with the securing screw on the right-front side of the pen carriage. *Do not cut the excess cable.* Check to be sure the drive cable lies in the grooves of the appropriate pulleys.

8. Move the carriage manually back and forth to work slack out of the cable. After each move from one end to the other, loosen a securing screw and remove any slack that appears, then retighten the securing screw. Do not cut the excess cable.

9. Proceed to the Y axis. Have a pair of tweezers or needle-nose pliers available. With approximately 11 feet of the smaller diameter Y axis cable (.018 inch diameter, Tektronix Part No. 214-2001-00), thread each end of the cable through a hole from the inside of the Y axis drive pulley so that equal amounts of cable protrude. The Y axis drive pulley is the larger of the two and is to be secured to the drive shaft of the motor to the right of the plotter.

10. Manually move the pen carriage to its front plotting position on the Y axis. Turn the Y axis drive pulley so the cables protrude from the front (90° to the left side of the drive shaft).

11. Refer to Fig. 3-16. Using the top cable, wind 5-3/4 clockwise turns around the Y axis drive pulley. From the bottom of the drive pulley, feed the same cable under pulley H, over pulley J, through the pulley arrangement in the pen carriage, and secure the cable to the plotter chassis at the left of the panel switches. To thread the cable through the pulley arrangement in the pen carriage, push the cable end in at the right side of the front pulley. The internal geometry is such that the cable will circle around and exit from the left side of the front pulley. *Do not cut the excess cable.*

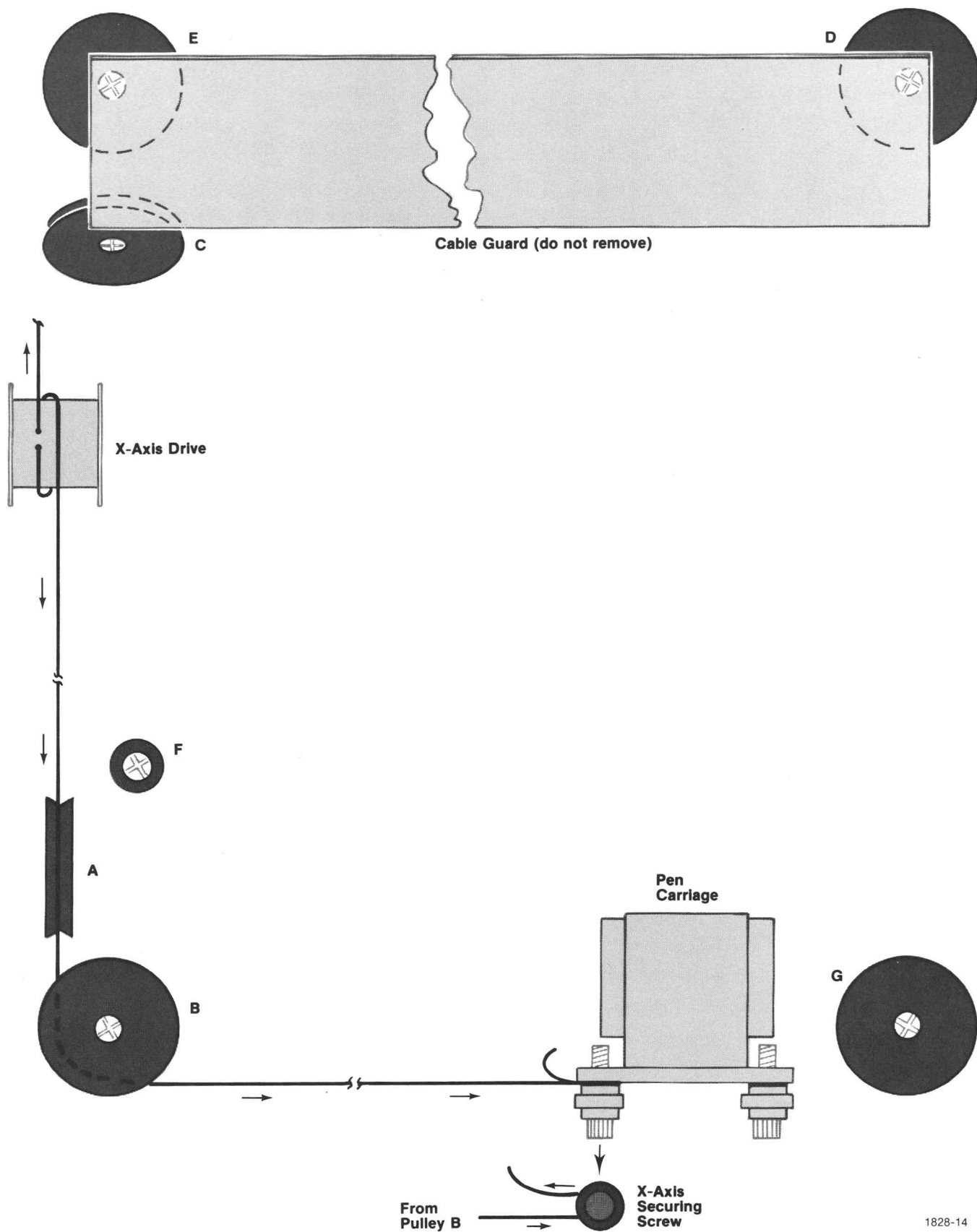


Fig. 3-14. X-Axis Cable Stringing—Part 1.

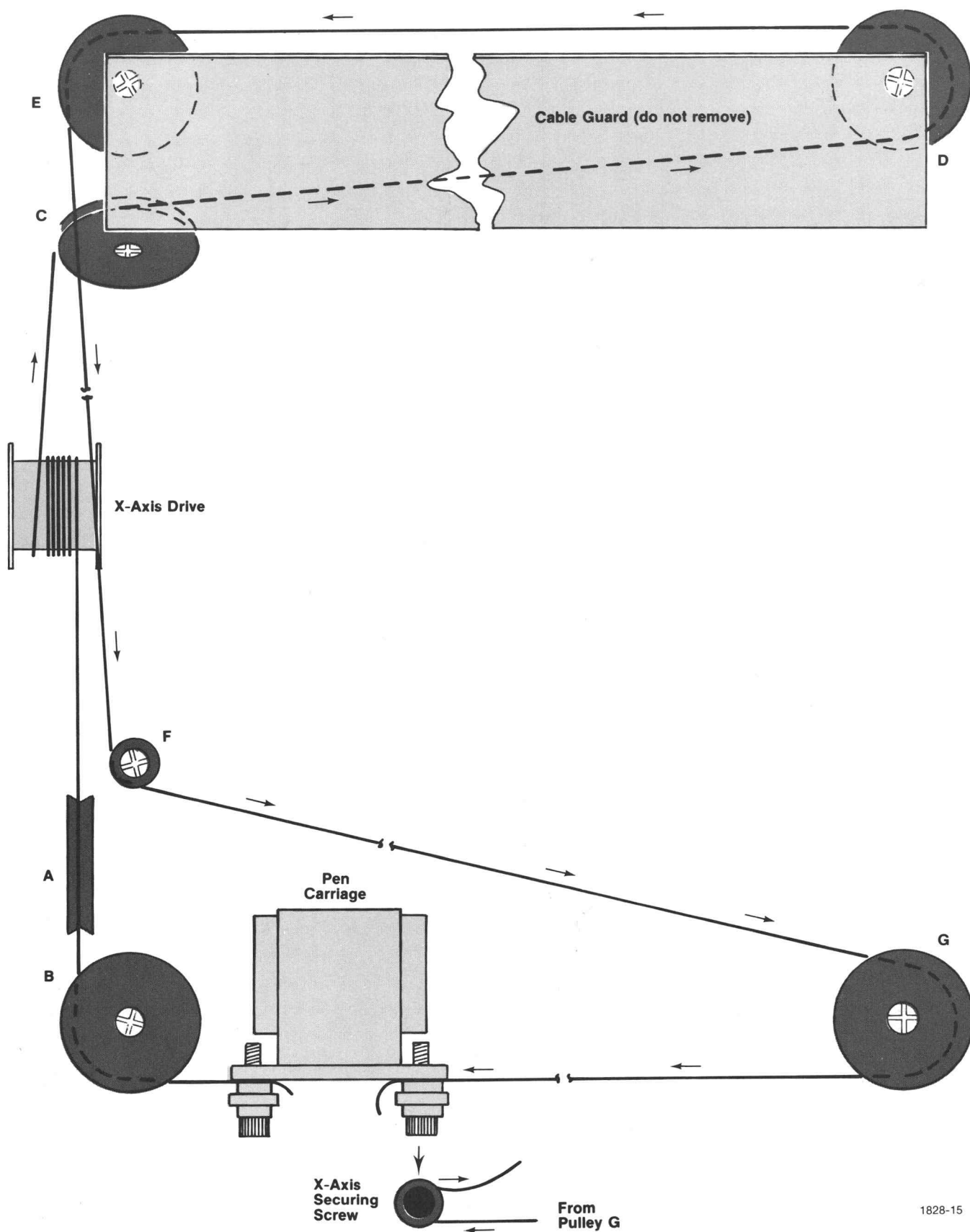


Fig. 3-15. X-Axis Cable Stringing—Part 2.

1828-15



12. Take the other drive cable counterclockwise underneath the Y axis drive pulley. Refer to Fig. 3-16. Feed the cable under pulley K, over pulley L, through the back pulley assembly of the pen carriage, and secure the cable to the chassis post at the left rear corner of the Plotter. The internal geometry of the pen carriage is such that if the cable is inserted to the left of the rear pulley, it will circle around and exit from the right side of that pulley (looking from behind the instrument).

13. Check to be sure the Y axis drive cables lie in the grooves of the appropriate pulleys. Move the carriage manually up and back to take up slack in the drive cables. After each move from one end to the other, loosen a cable securing screw and remove any slack which appears, then retighten the securing screw.

14. Adjust the cable tensions as specified in the following text.

### Drive Cable Tension Adjustments

After installing new drive cables in the Plotter and before trimming the excess, the cable tension should be adjusted using the following procedure:

1. Check to see that all the drive cables are in the grooves of the pulleys.

2. Manually move the pen carriage several times across the Plotter in both the X and Y axis to equalize the drive cables and take up slack.

3. The X axis cable should be disconnected from the single cable retaining screw on the rear end of the pen carriage (see Fig. 3-17). The retaining screw uses a 3/16-inch allen wrench.

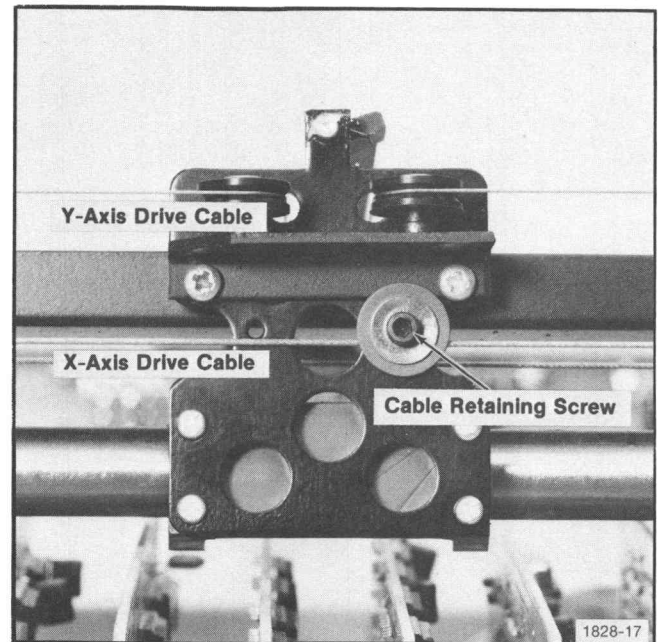


Fig. 3-17. Rear of pen carriage drive assembly.

4. Refer to Fig. 3-18. Tie one end of the Y axis cable to a spring tension gauge and loosen the securing screw; leave the other end of the drive cable fastened.

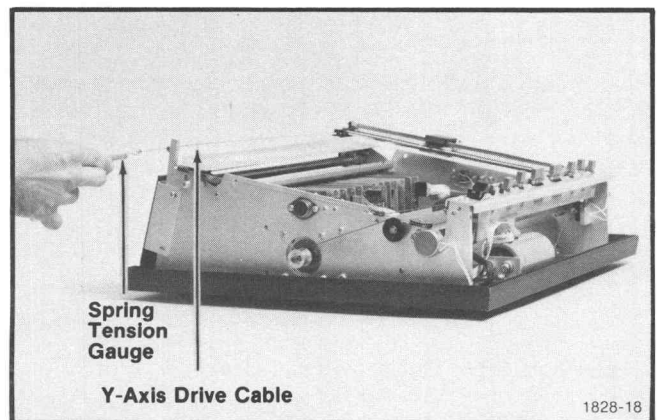


Fig. 3-18. Y-Axis Tension Adjustments.

5. Pull a spring tension of  $2\frac{1}{4} \pm \frac{1}{4}$ -lb on the Y axis drive cable and fasten the cable with the securing screw.

## Maintenance—4661 Service

6. Refer to Fig. 3-19. Position the pen carriage to the right most position of the plotter. Tie the right side of the X axis drive cable to the spring tension gauge. Loosen the right securing screw on the pen carriage. With the drive cable making a half loop around the screw, pull a tension of  $5\text{--}1\frac{1}{4} \pm 1\frac{1}{4}$  lb on the X axis drive cable and retighten the securing screw.

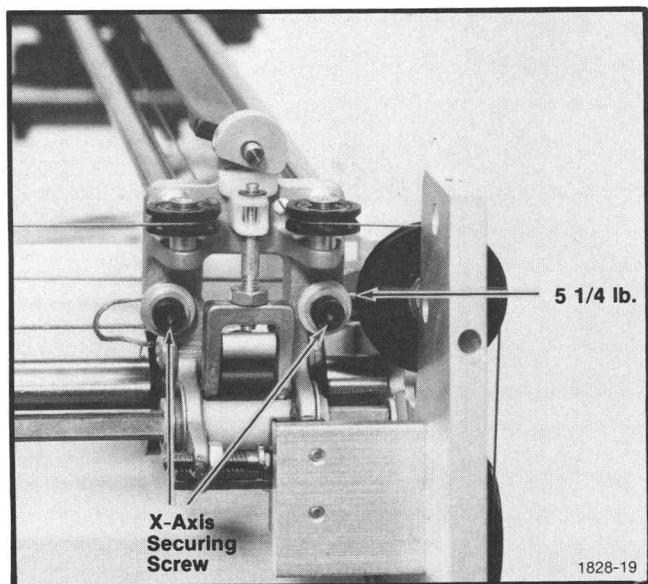


Fig. 3-19. X-Axis Tension Adjustment.

7. There is a cable retaining screw on the back side of the pen carriage. See Fig. 3-17. Using a 3/16 inch allen wrench, loosen the retaining screw, place the X axis drive cable between the washer and the pen carriage, and tighten the cable retaining screw.

8. Trim all excess drive cable.

9. Replace the plotter switch panel on the front of the Plotter.

10. Align the pen carriage after replacing the platen on the plotter. Do not install the case at this time.

### Pen Carriage Alignment

The pen carriage alignment requires a plotter configuration illustrated in Fig. 3-20. The platen must be mounted without the plotter case. Items needed are ruled plotter paper, a 1/16 inch allen wrench, a 7/64 inch allen wrench, a small 1/4 inch open end wrench, and a #1 point Phillips screwdriver.

1. Install the platen using the appropriate steps in the procedure titled Reassembly of Case and Platen; do not put on the case. See Fig. 3-20.

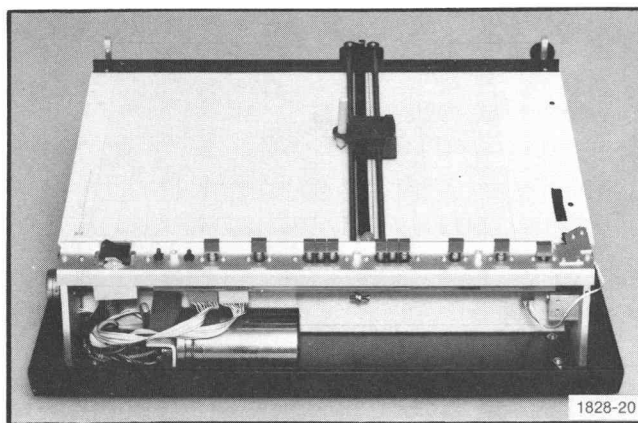


Fig. 3-20. Plotter setup for carriage alignments. The platen is installed without the plotter case.

2. Connect the plotter to a TEKTRONIX 21 or 31 Programmable Calculator, and turn on the calculator.

3. Place ruled plotter paper on the platen. It must be carefully positioned along the paper guide at the bottom and at the left edge of the platen.

### WARNING

*Hazardous voltages appear at several places within the plotter when the power is turned on.*

4. Turn on the power to the plotter; the pen carriage should move to the front right corner and close the two microswitches.

5. An initial zero is established to coincide with the lower left corner of the chart grid. To test for the location, enter the following sequence into the calculator:

Clear Display, Remote 31, Remote 32, Remote 33

The pen should move and lower precisely to the grid corner. If the pen does not come down precisely on the grid corner, the adjustments of steps 6 or 7 are to be performed after turning off the power to the 4661 Plotter. Then repeat steps 4 and 5.

If the pen falls on the grid zero point (the lower left corner), go to step 8 and continue.

6. To move the initial zero position left or right (see Fig. 3-21), locate the horizontal adjustment and move it right or left, respectively. This adjustment determines the pen carriage position when the X axis microswitch closes. Use a 1/4 inch open end wrench to turn the lock nut on the horizontal stop adjustment.

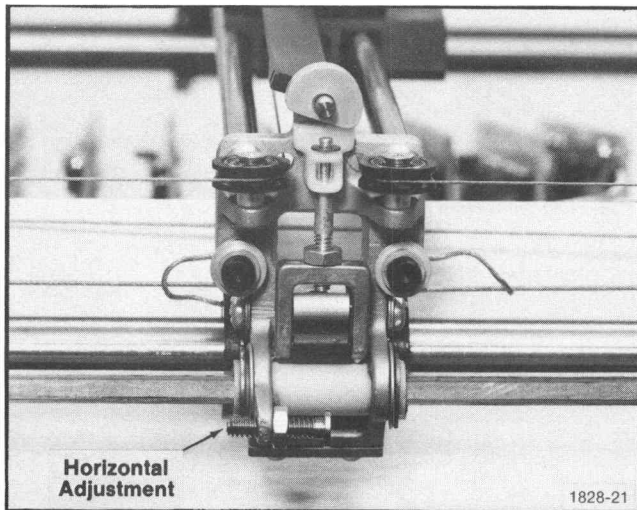


Fig. 3-21. Horizontal Position Adjustments.

7. To move the initial zero position up or down (see Fig. 3-22) locate the vertical adjustment. Two screws secure the Y axis microswitch in the adjustment slots. The position of the microswitch determines the initial zero vertical position on the chart paper. Tighten the screws after each adjustment.

8. Plot a horizontal line. If the line does not parallel the grid lines of the plotter paper, loosen the four platen screws (1/16 inch allen) and adjust the platen accordingly. Tighten the platten screws and repeat step 8 if necessary.

9. Plot a vertical line. If the line does not parallel the grid lines of the plotter paper (refer to Fig. 3-17), loosen the cable retaining screw on the rear of the plotter and move the pen carriage accordingly to obtain a vertical line. Tighten the cable retaining screw to secure the X axis drive cable after each adjustment. Repeat step 9 if necessary.

10. Repeat steps 4 and 5 to recheck the initial zero position.

11. Turn off the power. Remove the platten, Reassemble the plotter using the procedure titled "Reassembly of Case and Platen."

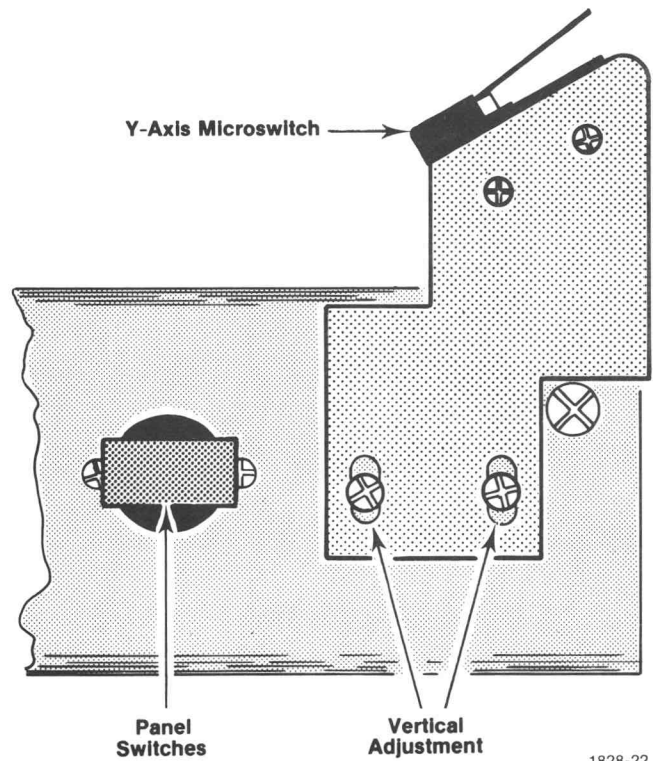


Fig. 3-22. Initial Zero Vertical Adjustments.

## CRITICAL MECHANICAL ADJUSTMENTS

### General

The procedures for routine maintenance are discussed near the beginning of the Service section. These procedures include cleaning, lubrication, wire stringing, platen alignment, and pen carriage alignment procedures. Other than lubrication, wire stringing, and alignment procedures for the pen carriage and platen, no other mechanical adjustments should be necessary.

If, however, the pen carriage has to be disassembled for repair, the following critical mechanical adjustments should be performed during reassembly. These adjustments should be performed only by a qualified mechanical technician. These critical adjustments pertain to the pen actuator assembly and the pen holder assembly.

### Equipment Needed

Allen wrenches:

7/64 inch, 3/32 inch, 1/16 inch, and .050 inch.

Phillips screwdrivers:

#1 point, #2 point.

## Maintenance—4661 Service

Blade screwdriver—preferably an offset blade.

1/4 inch open end wrench.

Small pliers.

Load gauge:

7 to 8 grams (some phonograph stylus pressure gauges may work).

New Plotter Pen.

Feeler gauge:

.035 inch.

For assembly and disassembly information, refer to the Mechanical Parts List.

### Linear Bearing Adjustment

The linear bearing is the sleeve of the pen actuator assembly that rides along the front X axis shaft (not the pen solenoid shaft). See Fig. 3-23. For adjustment or replacement, it is necessary that the pen carriage and front axis shafts be disassembled.

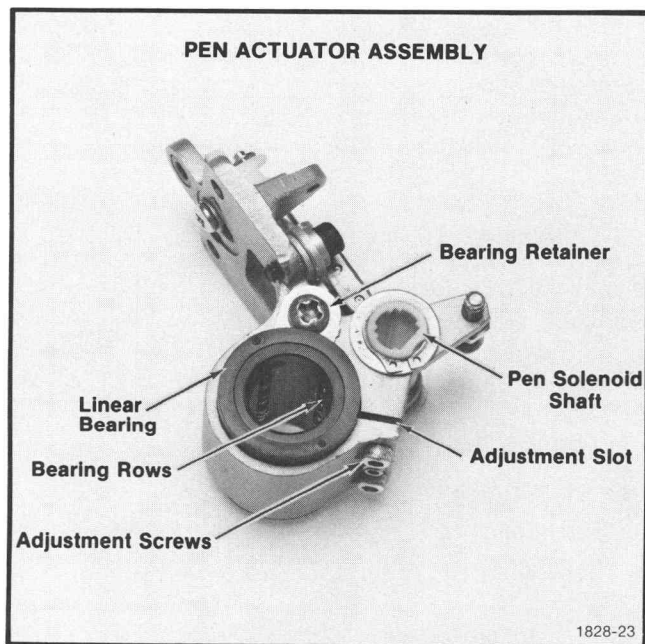


Fig. 3-23. Linear Bearing Adjustments.

1. Loosen the adjustment screws, especially the center one.

2. Install a linear bearing in the pen actuator assembly. Fasten it with the bearing retainer clamps.

3. Rotate the linear bearing in the pen assembly to align the bearing rows equidistant about the adjustment slot. See Fig. 3-23.

4. Place the front 1/2 inch X axis shaft through the linear bearing. This shaft does *not* have beveled edges or a notch in one end.

5. Hold the X axis shaft and pen actuator assembly at an approximate 45° angle. Tighten the outer two adjustment screws equally until the pen actuator assembly slides freely along the shaft without binding.

6. Still holding the X axis shaft at approximately 45°, position the pen actuator assembly to the top of the shaft and release. It should not move until tapped gently with a finger, thus causing it to slide freely down the shaft. When this adjustment is reached, tighten the center setscrew.

7. Reverse the shaft position (the other end at 45°) and repeat the test of step 6; adjust if necessary.

8. The pen actuator assembly and X axis shafts now are ready to be installed in the Plotter.

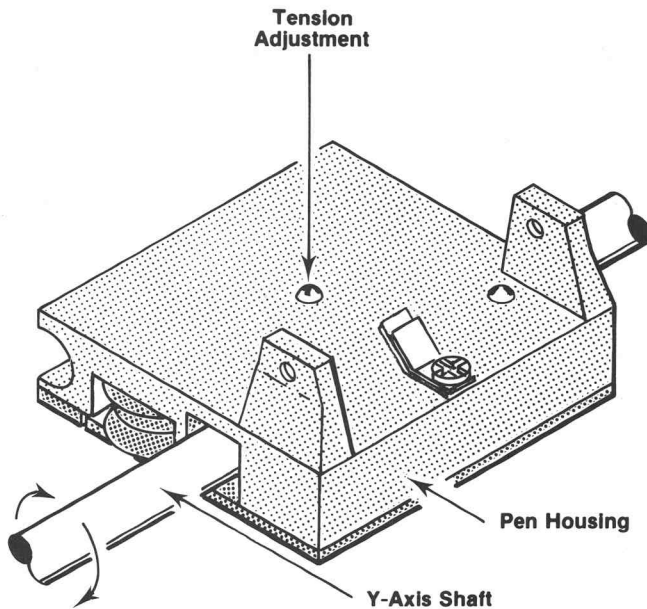
### Pen Housing Slide Tension

This procedure requires that the pen housing and its Y axis shaft(s) be removed from the Plotter. See Fig. 3-24. Refer to the Mechanical Parts List for parts illustrations when disassembling the pen carriage assembly.

1. Loosen slightly (do not remove) the hex nut that fastens to the tension adjustment screw. See Fig. 3-24.

2. Place the Y axis shaft in the pen housing. Internal to the housing there are 3 rollers, one of which is for tension.

3. Turn the tension adjustment (the center screw) counterclockwise just until all noticeable play around the Y axis shaft is removed. The pen housing should slide freely without binding.



1828-24

Fig. 3-24. Pen Housing and Slide Tension Adjustments.

4. Test the tension by holding the Y axis shaft and pen housing horizontally and slowly rotate the assembly as shown in Fig. 3-24. The pen housing should not slip, but should rotate with the shaft. If slippage occurs, tighten the screw slightly counterclockwise until corrected. The assembly should still slide freely along the shaft.

5. Tighten the hex nut on the tension screw to ensure the tension adjustment does not change.

### Pen Pressure Adjustments

These adjustments are best accomplished when the pen holder assembly, Fig. 3-25, is removed from the plotter. However, the adjustments may also be performed without removing the pen holder assembly, thus eliminating the need to restring new cables.

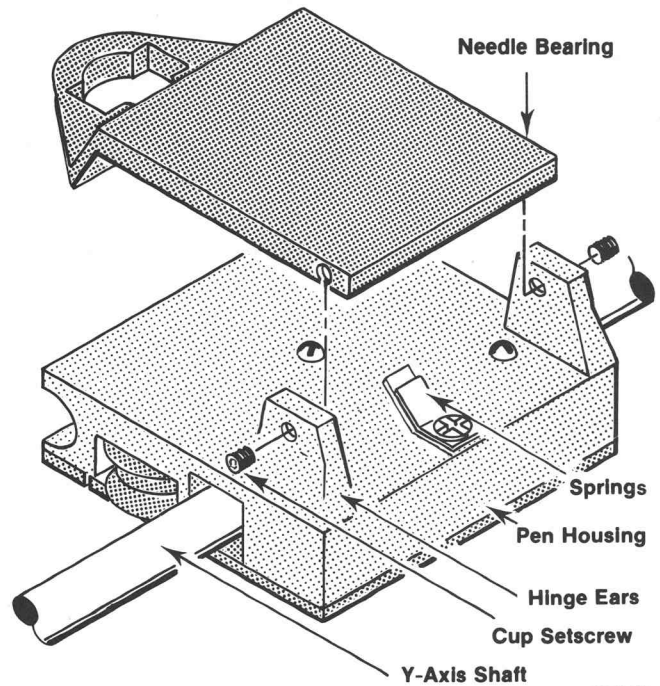
1. Install both leaf springs in the pen housing with the small spring on top. See Fig. 3-25.

#### CAUTION

*Cup setscrews may damage the needle bearings if adjusted too tightly.*

2. Install the hinge or pen holder. The cup setscrews should be adjusted very lightly on the needle bearings; tight enough to prevent side wobble and loose enough to freely pivot.

3. Install a new pen in the pen holder and remove the pen cap.



1828-25

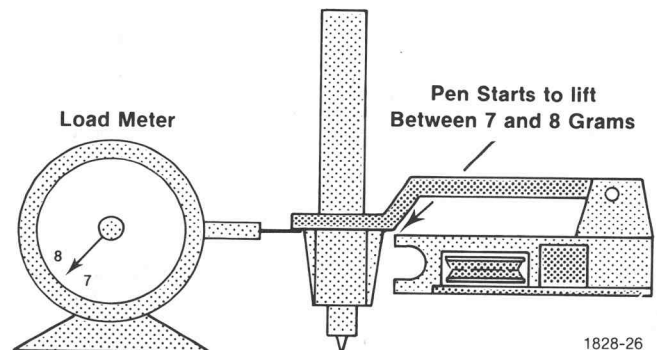
Fig. 3-25. Pen Holder Assembly, partially exploded.

4. Check the pen load with a new pen installed. See Fig. 3-26. Test for a pen load of 7 to 8 grams using a precision load meter. (Some phonograph stylus pressure gauges may work.) The load measurement should be made as the pen holder just starts to lift from the housing. A load greater than 8 grams will cause excessive pen wear. A load less than 7 grams may cause a broken plotting line.

5. If the pen pressure is too light, bend the springs slightly toward the hinge (Fig. 3-25).

6. If the pen pressure is too heavy, bend the springs slightly toward the pen housing (Fig. 3-25).

7. The pen carriage, including all axis shafts, pen actuator assembly, pen holder assembly, pen actuation cam, and pen actuating bar, is ready to be assembled. Refer to Fig. 3-27. Also refer to the Mechanical Parts List.



1828-26

Fig. 3-26. Measuring pen pressure in grams.

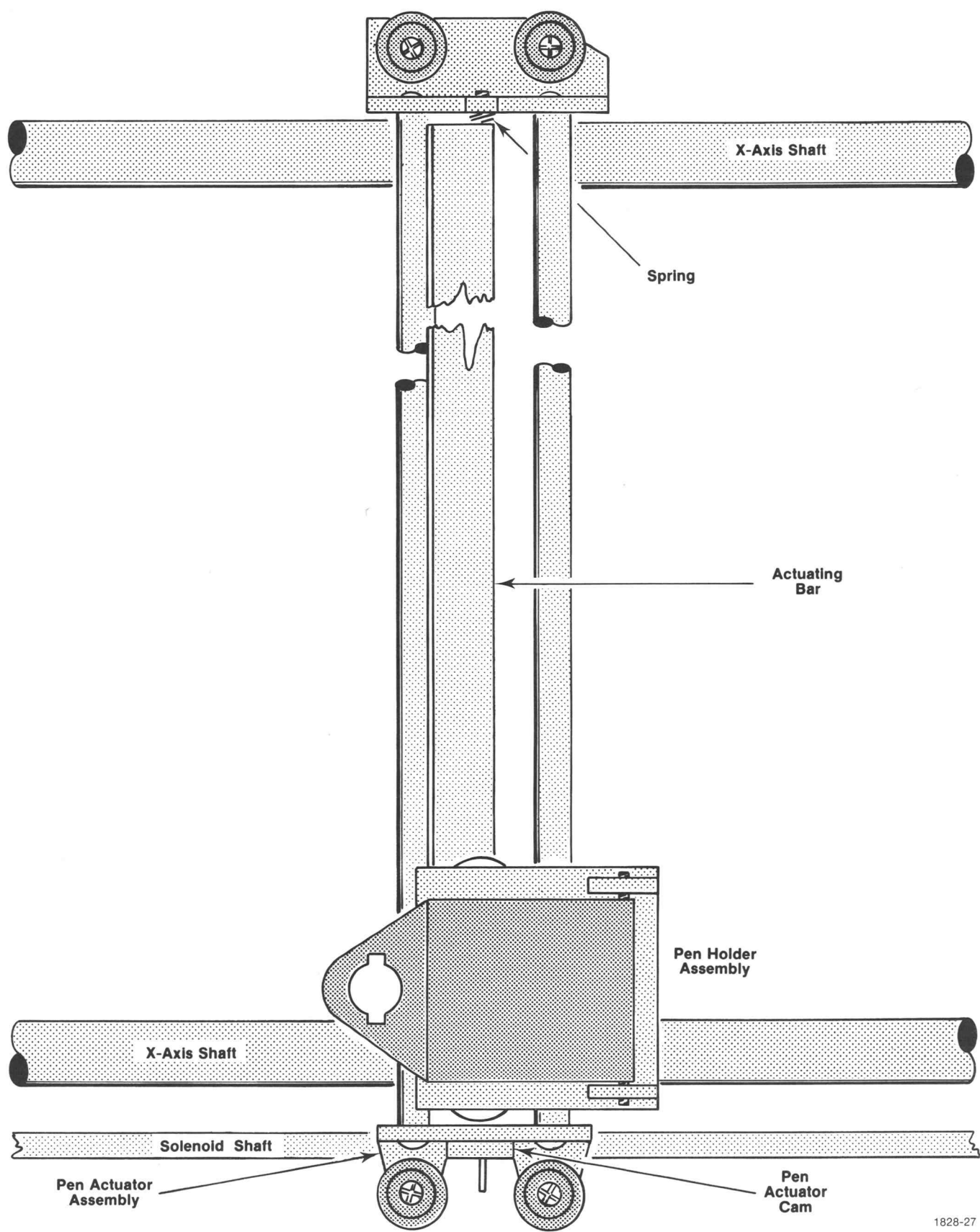


Fig. 3-27. Pen Carriage.

### Pen Actuator Assembly Adjustments

This procedure is to be performed after the entire pen carriage is assembled. The drive cables may or may not be strung at this time. This procedure adjusts the pen activation mechanics to ensure that the pen lowers to the plotting surface or lifts from the plotting surface when commanded.

1. Install the pen carriage (Fig. 3-27). Refer to the Mechanical Parts List if necessary.
2. Loosen the two allen screws on the pen actuation cam.
3. Insert a .035 inch thickness gauge (*ie.* a feeler gauge) between the pen actuation cam and the actuation plunger (Fig. 3-28).
4. With a small pair of pliers and a 1/4 inch open end wrench, adjust the pen actuation assembly hex nut and the plunger shaft for a gap of .035 inch between the plunger and the pen actuation cam (see Fig. 3-28). Tighten the hex nut to secure the adjustment.

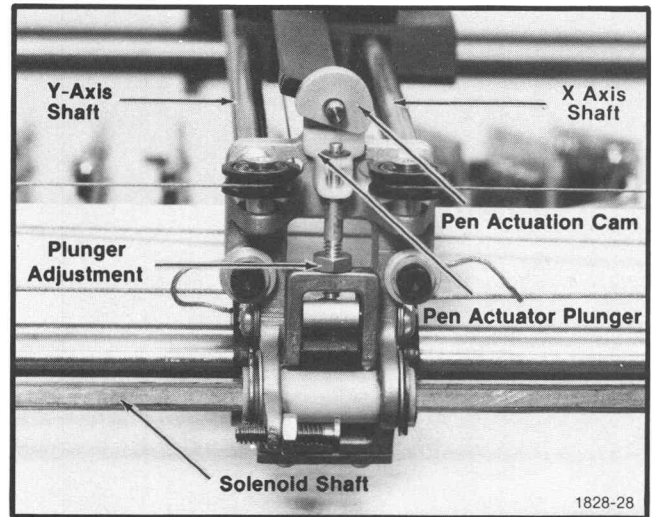


Fig. 3-28. Pen Actuator Assembly.

5. With the .035 inch gauge in place, hold the pen actuating bar in a horizontal position and tighten the two allen setscrews securing the pen actuation cam to the actuating bar.
6. Remove all tools and gauges and proceed with the wire stringing procedure in the mechanical adjustments section if necessary.



# REPLACEABLE ELECTRICAL PARTS

## PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

## SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number  
00X Part removed after this serial number

## ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

## ABBREVIATIONS

ACTR	ACTUATOR	PLSTC	PLASTIC
ASSY	ASSEMBLY	QTZ	QUARTZ
CAP	CAPACITOR	RECP	RECEPTACLE
CER	CERAMIC	RES	RESISTOR
CKT	CIRCUIT	RF	RADIO FREQUENCY
COMP	COMPOSITION	SEL	SELECTED
CONN	CONNECTOR	SEMICOND	SEMICONDUCTOR
ELCTLT	ELECTROLYTIC	SENS	SENSITIVE
ELEC	ELECTRICAL	VAR	VARIABLE
INCAND	INCANDESCENT	WW	WIREWOUND
LED	LIGHT EMITTING DIODE	XFMR	TRANSFORMER
NONWIR	NON WIREWOUND	XTAL	CRYSTAL

## CROSS INDEX MFR. CODE NUMBER TO MANUFACTURER

MFR.CODE	MANUFACTURER	ADDRESS	CITY,STATE,ZIP
01121	Allen-Bradley Co.	1201 2nd St. South	Milwaukee, WI 53204
01295	Texas Instruments, Inc., Semiconductor Group	P. O. Box 5012	Dallas, TX 75222
01637	Motorcraft	1219 S. Walnut Street	Muncie, IN 47302
01884	Sprague Electric Co., Dearborn Electronics Div. DELETED, Replace by: 56289		
01963	Cherry Electrical Products Corp.	3600 Sunset Ave.	Waukegan, IL 60085
02735	RCA Corp., Solid State Division	Route 202	Somerville, NY 08876
03508	General Electric Co., Semi-Conductor Products Dept.	Electronics Park	Syracuse, NY 13201
04713	Motorola, Inc., Semiconductor Products Div.	5005 E. McDowell Rd.	Phoenix, AZ 85036
05245	Components Corp.	2857 Halsted St.	Chicago, IL 60657
05721	Beckman Instruments Inc., Scientific Instruments Div.	2500 Harbor Blvd.	Fullerton, CA 92634
07263	Fairchild Semiconductor, A Div. of Fairchild Camera and Instrument Corp.	464 Ellis St.	Mountain View, CA 94042
07910	Teledyne Semiconductor	12515 Chadron Ave.	Hawthorne, CA 90250
14936	General Instrument Corp., Semiconductor Products Group	600 W. John St.	Hicksville, NY 11802
18324	Signetics Corp.	811 E. Arques	Sunnyvale, CA 94086
27014	National Semi-Conductor Corp.	2900 San Ysidro Way	Santa Clara, CA 95051
27193	Cutler-Hammer, Inc. Specialty Products Division	4201 N. 27th St.	Milwaukee, WI 53216
28480	Hewlett-Packard Co., Corporate Hq.	1501 Page Mill Rd.	Palo Alto, CA 94304
32284	Rotron Controls Div. of Rotron Inc.,	7-9 Hasbrouck Lane	Woodstock NY 12498
34371	Harris Semiconductor, Div. of Harris-Intertype Corp.	P. O. Box 883	Melbourne, FL 32901
56289	Sprague Electric Co.		North Adams, MA 01247
71400	Bussman Mfg., Division of McGraw- Edison Co.	2536 W. University St.	St. Louis, MO 63107
71590	Centralab Electronics, Div. of Globe-Union, Inc.	5757 N. Green Bay Ave.	Milwaukee, WI 53201
72421	Sigma Instruments, Inc., Fisher-Price Div.	170 Pearl St. South	Braintree, MA 02185
72982	Erie Technological Products, Inc.	644 W. 12th St.	Erie, PA 16512
75042	TRW Electronic Components, IRC Fixed Resistors, Philadelphia Division	401 N. Broad St.	Philadelphia, PA 19108
80009	Tektronix, Inc.	P. O. Box 500	Beaverton, OR 97077
80294	Bourns, Inc., Instrument Div.	6135 Magnolia Ave.	Riverside, CA 92506
81483	International Rectifier Corp.	9220 Sunset Blvd.	Los Angeles, CA 90069
81840	Ledex Div, Ledex Inc.	123 Webster St.	Dayton, OH 45402
83003	Varo, Inc.	800 W. Garland Ave.	Garland, TX 75040
90201	Mallory Capacitor Co., Div. of P. R. Mallory Co., Inc.	3029 E. Washington St.	Indianapolis, IN 46206
91637	Dale Electronics, Inc.	P. O. Box 609	Columbus, NB 68601

Ckt No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Name & Description	Mfr Code	Mfr Part Number
A1 <sup>1</sup>	670-3388-00		CKT BOARD ASSY:POWER REGULATOR	80009	670-3388-00
A2	670-3412-00		CKT BOARD ASSY:STEP DRIVE	80009	670-3412-00
A3	670-3395-00		CKT BOARD ASSY:VELOCITY COMP	80009	670-3395-00
A4	670-3396-00		CKT BOARD ASSY:VELOCITY GENERATOR	80009	670-3396-00
A5	670-3417-00		CKT BOARD ASSY:PANEL INTERFACE	80009	670-3417-00
A6	670-3419-00		CKT BOARD ASSY:TIMING	80009	670-3419-00
A7	670-3505-00		CKT BOARD ASSY:PROGRAMMER	80009	670-3505-00
A8	670-3502-00		CKT BOARD ASSY:OFF SCALE	80009	670-3502-00
A9	670-3454-00		CKT BOARD ASSY:DATA	80009	670-3454-00
A10	670-3494-00		CKT BOARD ASSY:AXIS	80009	670-3494-00
A11	670-3421-00		CKT BOARD ASSY:DATA CONVERTER	80009	670-3421-00
A12	670-3457-00		CKT BOARD ASSY:CAL INTERFACE NO. 2	80009	670-3457-00
A13	670-3456-00		CKT BOARD ASSY:CAL INTERFACE NO. 1	80009	670-3456-00
A14	670-3497-00		CKT BOARD ASSY:MOTHER	80009	670-3497-00
A15	670-3398-00		CKT BOARD ASSY:I.O.	80009	670-3398-00
A16	670-3522-00		CKT BOARD ASSY:ELECTROSTATIC	80009	670-3522-00
A17	670-3629-00		CKT BOARD ASSY:PANEL SWITCH	80009	670-3629-00
A1	670-3388-00		CKT BOARD ASSY:POWER REGULATOR	80009	670-3388-00
C1	290-0529-00		CAP.,FXD,ELCTLT:47UF,20%,20V	56289	196D476X0020LA3
C2	290-0533-00		CAP.,FXD,ELCTLT:330UF,20%,6V	56289	196D337X006MA3
C3	290-0517-00		CAP.,FXD,ELCTLT:6.8UF,20%,35VDC	90201	196D685X0035KA1
C4	283-0010-00		CAP.,FXD,CER DI:0.05UF,+100-20%,50V	56289	273C20
C5	290-0517-00		CAP.,FXD,ELCTLT:6.8UF,20%,35VD	90201	196D685X0035KA1
C6	283-0177-00		CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C7	285-0809-00		CAP.,FXD,PLSTC:1UF,10%,50V	01884	LP88A1A105K
C8	290-0577-00		CAP.,FXD,ELCTLT:2000UF,50V	56289	68D10504
C9	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C10	283-0077-00		CAP.,FXD,CER DI:330PF,5%,500V	56289	40C94A3
C11	283-0279-00		CAP.,FXD,CER DI:0.001UF,20%,3000V	72982	878Y5S102M
C12	283-0279-00		CAP.,FXD,CER DI:0.001UF,20%,3000V	72982	878Y5S102M
CR1	152-0423-00		SEMICONV DEVICE:SILICON,300V,3A	04713	SR2052K
CR2	152-0066-00		SEMICONV DEVICE:SILICON,400V,750MA	02735	1N3194
CR3	152-0066-00		SEMICONV DEVICE:SILICON,400V,750MA	02735	1N3194
CR4	152-0141-02		SEMICONV DEVICE:SILICON,30V,150MA	07910	CD8220
CR5	152-0141-02		SEMICONV DEVICE:SILICON,30V,150MA	07910	CD8220
CR6	152-0385-00		SEMICONV DEVICE:SILICON,2000V,100MA	83003	VB20
CR7	152-0385-00		SEMICONV DEVICE:SILICON,2000V,100MA	83003	VB20
Q1	151-0349-00		TRANSISTOR:SILICON,NPN SEL FROM MJE2801	80009	151-0349-00
Q2	151-0349-00		TRANSISTOR:SILICON,NPN SEL FROM MJE2801	80009	151-0349-00
Q3	151-0323-00		TRANSISTOR:SILICON,NPN SEL FROM MJE521	04713	SJE916
Q4	151-0405-00		TRANSISTOR:SILICON,NPN,SEL FROM MJE800	04713	SJE943
Q5	151-0302-00		TRANSISTOR:SILICON,NPN	04713	2N2222A
Q6	151-0302-00		TRANSISTOR:SILICON,NPN	04713	2N2222A
Q7	151-0301-00		TRANSISTOR:SILICON,PNP	04713	2N2907A
Q8	151-0302-00		TRANSISTOR:SILICON,NPN	04713	2N2222A
Q9	151-0301-00		TRANSISTOR:SILICON,PNP	04713	2N2907A
Q10	151-0364-00		TRANSISTOR:SILICON,PNP	03508	X43C181
Q11	151-0426-00		TRANSISTOR:SILICON,NPN	03508	D44H11

<sup>1</sup>Qty of 2 per unit.

# Electrical Parts List—4661

Ckt No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Name & Description	Mfr Code	Mfr Part Number
Q12	151-0515-01		TRANSISTOR:50V,8A	04713	2N4441
Q14	151-0302-00		TRANSISTOR:SILICON,NPN	04713	2N2222A
R1	308-0757-00		RES.,FXD,WW:0.25 OHM,3%,5W	91637	LVR5-GRO250H
R2	308-0757-00		RES.,FXD,WW:0.25 OHM,3%,5W	91637	LVR5-GRO250H
R3	308-0757-00		RES.,FXD,WW:0.25 OHM,3%,5W	91637	LVR5-GRO250H
R4	315-0430-00		RES.,FXD,COMP:43 OHM,5%,0.25W	01121	CB4305
R5	315-0751-00		RES.,FXD,COMP:750 OHM,5%,0.25W	01121	CB7515
R6	315-0331-00		RES.,FXD,COMP:330 OHM,5%,0.25W	01121	CB3315
R7	315-0331-00		RES.,FXD,COMP:330 OHM,5%,0.25W	01121	CB3315
R8	315-0430-00		RES.,FXD,COMP:43 OHM,5%,0.25W	01121	CB4305
R9	321-0255-00		RES.,FXD,FILM:4.42K OHM,1%,0.125W	75042	CEATO-4421F
R10	311-1225-00		RES.,VAR,NONWIR:1K OHM,20%,0.50W	80294	3389F-P31-102
R11	321-0247-00		RES.,FXD,FILM:3.65K OHM,1%,0.125W	75042	CEATO-3651F
R12	315-0123-00		RES.,FXD,COMP:12K OHM,5%,0.25W	01121	CB1235
R13	315-0100-00		RES.,FXD,COMP:10 OHM,5%,0.25W	01121	CB1005
R20	307-0055-00		RES.,FXD,COMP:3.9 OHM,5%,0.50W	01121	EB39G5
R21	315-0183-00		RES.,FXD,COMP:18K OHM,5%,0.25W	01121	CB1835
R22	315-0391-00		RES.,FXD,COMP:390 OHM,5%,0.25W	01121	CB3915
R23	321-0239-00		RES.,FXD,FILM:3.01K OHM,1%,0.125W	75042	CEATO-3011F
R24	321-0284-00		RES.,FXD,FILM:8.87K OHM,1%,0.125W	75042	CEATO-8871F
R25	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R26	315-0473-00		RES.,FXD,COMP:47K OHM,5%,0.25W	01121	CB4735
R30	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R31	315-0202-00		RES.,FXD,COMP:2K OHM,5%,0.25W	01121	CB2025
R32	303-0242-00		RES.,FXD,COMP:2.4K OHM,5%,1W	01121	GB2425
R33	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R34	315-0333-00		RES.,FXD,COMP:33K OHM,5%,0.25W	01121	CB3335
R35	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R36	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R37	303-0102-00		RES.,FXD,COMP:1K OHM,5%,1W	01121	GB1025
R38	308-0297-00		RES.,FXD,WW:24.7 OHM,1%,3W	01637	RS2B-K24R70F
R39	315-0203-00		RES.,FXD,COMP:20K OHM,5%,0.25W	01121	CB2035
R40	315-0105-00		RES.,FXD,COMP:1M OHM,5%,0.25W	01121	CB1055
R41	315-0103-00		RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R42	315-0105-00		RES.,FXD,COMP:1M OHM,5%,0.25W	01121	CB1055
R43	301-0226-00		RES.,FXD,COMP:22M OHM,5%,0.50W	01121	EB2265
R44	301-0226-00		RES.,FXD,COMP:22M OHM,5%,0.50W	01121	EB2265
R45	315-0220-00		RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
T2	120-0929-00		XFMR,PWR,SDN + SU:POT CORE	80009	120-0929-00
U1	156-0374-00		MICROCIRCUIT,DI:2-INPUT NOR BUFFER	01295	SN7438N
U2	156-0405-00		MICROCIRCUIT,DI:DUAL RETRIG MONOSTABLE MV	07263	9602PC
U3	156-0158-00		MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	18324	S5558V
VR1	152-0175-00		SEMICONV DEVICE:ZENER,0.4W,5.6V,5%	04713	1N752A
VR2	152-0395-00		SEMICONV DEVICE:ZENER,0.4W,4.3V,5%	07910	1N749A
VR3	152-0306-00		SEMICONV DEVICE:ZENER,0.4W,9.1V,5%	81483	1N960B
VR4	152-0212-00		SEMICONV DEVICE:ZENER,0.5W,9V,5%	04713	SZ50646

Ckt No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Name & Description	Mfr Code	Mfr Part Number
A2	670-3412-00		CKT BOARD ASSY:STEP DRIVE	80009	670-3412-00
C1	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C2	290-0114-00		CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C3	290-0528-00		CAP.,FXD,ELCTLT:15UF,20%,50V	90201	TDC156M050GL
C4	283-0051-00		CAP.,FXD,CER DI:0.0033UF,5%,100V	72982	8131N145C0G332J
CR1	152-0066-00		SEMICOND DEVICE:SILICON,400V,750MA	02735	1N3194
CR2	152-0333-00		SEMICOND DEVICE:SILICON,55V,200MA	07263	FDH6012
CR3	152-0141-02		SEMICOND DEVICE:SILICON,30V,150MA	07910	CD8220
CR5	152-0585-00		SEMICOND DEVICE:SWITCHING,75V,75MA	14936	WO2M
CR6	152-0585-00		SEMICOND DEVICE:SWITCHING,75V,75MA	14936	WO2M
Q1	151-0365-00		TRANSISTOR:SILICON,NPN	03508	X42C182
Q2	151-0365-00		TRANSISTOR:SILICON,NPN	03508	X42C182
Q3	151-0365-00		TRANSISTOR:SILICON,NPN	03508	X42C182
Q4	151-0365-00		TRANSISTOR:SILICON,NPN	03508	X42C182
Q5	151-0364-00		TRANSISTOR:SILICON,PNP	03508	X43C181
Q6	151-0219-00		TRANSISTOR:SILICON,NPN	07263	SO22650
Q7	151-0302-00		TRANSISTOR:SILICON,NPN	04713	2N2222A
Q8	151-0302-00		TRANSISTOR:SILICON,NPN	04713	2N2222A
Q9	151-0302-00		TRANSISTOR:SILICON,NPN	04713	2N2222A
Q10	151-0302-00		TRANSISTOR:SILICON,NPN	04713	2N2222A
Q11	151-0273-00		TRANSISTOR:SILICON,NPN	03508	X16P3616
Q12	151-0273-00		TRANSISTOR:SILICON,NPN	03508	X16P3616
Q13	151-0364-00		TRANSISTOR:SILICON,PNP	03508	X43C181
Q14	151-0364-00		TRANSISTOR:SILICON,PNP	03508	X43C181
Q15	151-0364-00		TRANSISTOR:SILICON,PNP	03508	X43C181
Q16	151-0364-00		TRANSISTOR:SILICON,PNP	03508	X43C181
Q17	151-0365-00		TRANSISTOR:SILICON,NPN	03508	X42C182
Q18	151-0365-00		TRANSISTOR:SILICON,NPN	03508	X42C182
Q19	151-0365-00		TRANSISTOR:SILICON,NPN	03508	X42C182
Q20	151-0365-00		TRANSISTOR:SILICON,NPN	03508	X42C182
R1	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R2	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R3	315-0163-00		RES.,FXD,COMP:16K OHM,5%,0.25W	01121	CB1635
R4	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R5	315-0822-00		RES.,FXD,COMP:8.2K OHM,5%,0.25W	01121	CB8225
R6	321-0251-00		RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R7	321-0222-00		RES.,FXD,FILM:2K OHM,1%,0.125W	75042	CEAT0-2001F
R8	321-0193-00		RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R9	321-0164-00		RES.,FXD,FILM:499 OHM,1%,0.125W	75042	CEAT0-4990F
R11	315-0222-00		RES.,FXD,COMP:2.2K OHM,5%,0.25W	01121	CB2225
R12	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R13	315-0202-00		RES.,FXD,COMP:2K OHM,5%,0.25W	01121	CB2025
R14	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R15	301-0820-00		RES.,FXD,COMP:82 OHM,5%,0.50W	01121	EB8205
R16	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R17	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R18	301-0820-00		RES.,FXD,COMP:82 OHM,5%,0.50W	01121	EB8205
R19	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R20	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R21	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R22	301-0820-00		RES.,FXD,COMP:82 OHM,5%,0.50W	01121	EB8205
R23	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R24	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R25	301-0820-00		RES.,FXD,COMP:82 OHM,5%,0.50W	01121	EB8205

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Ckt No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Name & Description	Mfr Code	Mfr Part Number
R26	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R27	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R30	308-0463-00		RES.,FXD,WW:0.3 OHM,1%,3W	91637	RS2B-ER3000F
R31	315-0470-00		RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R32	315-0472-00		RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R33	315-0472-00		RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R34	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R35	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R36	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R37	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R38	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
U1	156-0061-00		MICROCIRCUIT,DI:SGL,BCD TO DEC DECODER	01295	SN7442N
U2	156-0144-00		MICROCIRCUIT,DI:3-INPUT POS NAND GATE	01295	SN7412N
U3	156-0175-00		MICROCIRCUIT,DI:SYNCHRONOUS,4-BIT	01295	SN74191N
U4	156-0144-00		MICROCIRCUIT,DI:3-INPUT POS NAND GATE	01295	SN7412N
U5	156-0178-00		MICROCIRCUIT,DI:TRIPLE 3-INPUT NOR GATE	01295	SN7427N
U6	156-0058-00		MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U7	156-0153-00		MICROCIRCUIT,DI:HEX INVERT W/OPEN COIL	01295	SN7406N
A3	670-3395-00		CKT BOARD ASSY:VELOCITY COMP	80009	670-3395-00
C1	290-0114-00		CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C2	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C3	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C4	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C5	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
R1	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
U1	156-0248-00		MICROCIRCUIT,DI:FULLY SYNC BINARY COUNTER	01295	SN74163N
U2	156-0248-00		MICROCIRCUIT,DI:FULLY SYNC BINARY COUNTER	01295	SN74163N
U3	156-0248-00		MICROCIRCUIT,DI:FULLY SYNC BINARY COUNTER	01295	SN74163N
U4	156-0043-00		MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U5	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U6	156-0047-00		MICROCIRCUIT,DI:3-INPUT NAND GATE	01295	SN7410N
U7	156-0098-00		MICROCIRCUIT,DI:DUAL 4 LINE-1 LINE DATA SEL	01295	SN74153N
U9	156-0058-00		MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U10	156-0098-00		MICROCIRCUIT,DI:DUAL 4 TO 1 LINE DATA SEL	01295	SN74153N
U11	156-0061-00		MICROCIRCUIT,DI:SGL,BCD TO DEC DECODER	01295	SN7442N
U12	156-0171-00		MICROCIRCUIT,LI:QUAD 2-INPUT POS OR GATE	01295	SN7432N
U13	156-0222-00		MICROCIRCUIT,DI:HEX.LATCH	01295	SN74174N
U14	156-0087-00		MICROCIRCUIT,DI:4-BIT BINARY FULL ADDER	01295	SN7483N
U15	156-0087-00		MICROCIRCUIT,DI:4-BIT BINARY FULL ADDER	01295	SN7483N
U16	156-0222-00		MICROCIRCUIT,DI:HEX.LATCH	01295	SN74174N
U17	156-0043-00		MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U18	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U19	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U20	156-0222-00		MICROCIRCUIT,DI:HEX.LATCH	01295	SN74174N

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A4	670-3396-00			CKT BOARD ASSY:VELOCITY GENERATOR	80009	670-3396-00
C1	290-0114-00			CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C2	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C3	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C4	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C5	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
R1	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
U1	156-0131-00			MICROCIRCUIT,DI:8-BIT SER TO PARLLEL SHF	01295	SN74164N
U2	156-0148-00			MICROCIRCUIT,DI:DUAL FULL ADDER	07263	9304DC
U3	156-0221-00			MICROCIRCUIT,DI:QUAD LATCH	01295	SN74175N
U4	156-0085-00			MICROCIRCUIT,DI:DUAL 8-BIT SHIFT REGISTER	07263	9328DC
U5	156-0039-00			MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U6	156-0131-00			MICROCIRCUIT,DI:8-BIT SER TO PARLLEL SHF	01295	SN74164N
U7	156-0041-00			MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U8	156-0171-00			MICROCIRCUIT,LI:QUAD 2-INPUT POS OR GATE	01295	SN7432N
U9	156-0131-00			MICROCIRCUIT,DI:8-BIT SER TO PARLLEL SHF	01295	SN74164N
U10	156-0311-00			MICROCIRCUIT,DI:6-BIT BINARY RATE MULT	01295	SN7497N
U11	156-0047-00			MICROCIRCUIT,DI:3-INPUT NAND GATE	01295	SN7410N
U12	156-0043-00			MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U13	156-0062-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS EXCL GATE	04713	MC7486P
U14	156-0131-00			MICROCIRCUIT,DI:8-BIT SER TO PARLLEL SHF	01295	SN74164N
U15	156-0311-00			MICROCIRCUIT,DI:6-BIT BINARY RATE MULT	01295	SN7497N
U16	156-0129-00			MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U17	156-0058-00			MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U18	156-0098-00			MICROCIRCUIT,DI:DUAL 4 LINE-1 LINE DATA SEL	01295	SN74153N
U19	156-0030-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U20	156-0061-00			MICROCIRCUIT,DI:SGL,BCD TO DEC DECODER	01295	SN7442N
A5	670-3417-00			CKT BOARD ASSY:PANEL INTERFACE	80009	670-3417-00
C3	290-0527-00			CAP.,FXD,ELCTLT:15UF,20%,20V	90201	TDC156M020FL
C4	290-0531-00			CAP.,FXD,ELCTLT:100UF,20%,10V	90201	TDC107M010CL
C6	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C7	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C8	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C10	290-0114-00			CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C11	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C12	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C13	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C14	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C15	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
CR1	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	CD8220
CR2	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	CD8220
CR3	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	CD8220
CR4	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	CD8220
Q1	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
R1	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R2	315-0151-00			RES.,FXD,COMP:150 OHM,5%,0.25W	01121	CB1515
R3	315-0151-00			RES.,FXD,COMP:150 OHM,5%,0.25W	01121	CB1515
R4	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R5	315-0303-00			RES.,FXD,COMP:30K OHM,5%,0.25W	01121	CB3035

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Ckt No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Name & Description	Mfr Code	Mfr Part Number
R10	307-0406-00		RES.,FXD,FILM:NETWORK,4.3 AND 7.5K OHM,2%	05721	1898-68-0
R11	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R15	307-0406-00		RES.,FXD,FILM:NETWORK,4.3 AND 7.5K OHM,2%	05721	1898-68-0
U1	156-0405-00		MICROCIRCUIT,DI:DUAL RETRIG MONOSTABLE MV	07263	9602PC
U2	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U3	156-0062-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS EXCL GATE	04713	MC7486P
U4	156-0098-00		MICROCIRCUIT,DI:DUAL 4 LINE-1 LINE DATA SEL	01295	SN74153N
U5	156-0504-00		MICROCIRCUIT,DI:HEX BUFFER	34371	HD1-40L0-9
U7	156-0058-00		MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U8	156-0221-00		MICROCIRCUIT,DI:QUAD LATCH	01295	SN74175N
U9	156-0222-00		MICROCIRCUIT,DI:HEX.LATCH	01295	SN74174N
U11	156-0165-00		MICROCIRCUIT,DI:DUAL 4-INPUT POS NOR GATE	01295	SN7425N
U12	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U13	156-0041-00		MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U14	156-0503-00		MICROCIRCUIT,DI:HEX INVERTER BUFFER	34371	HD1-4009-9
U16	156-0178-00		MICROCIRCUIT,DI:TRIPLE 3-INPUT NOR GATE	01295	SN7427N
U17	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U18	156-0171-00		MICROCIRCUIT,LI:QUAD 2-INPUT POS OR GATE	01295	SN7432N
U19	156-0222-00		MICROCIRCUIT,DI:HEX.LATCH	01295	SN74174N
U20	156-0504-00		MICROCIRCUIT,DI:HEX BUFFER	34371	HD1-4010-9
A6	670-3419-00		CKT BOARD ASSY:TIMING	80009	670-3419-00
C1	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C2	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C3	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C4	290-0114-00		CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C5	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
R1	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R2	315-0103-00		RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R3	315-0103-00		RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R4	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R5	315-0203-00		RES.,FXD,COMP:20K OHM,5%,0.25W	01121	CB2035
U1	156-0150-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND BUFF	01295	SN7437N
U2	156-0374-00		MICROCIRCUIT,DI:QUAD 2-INPUT NOR BUFFER	01295	SN7428N
U3	156-0041-00		MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U4	156-0034-00		MICROCIRCUIT,DI:DUAL 4-INPUT NAND GATE	01295	SN7420N
U5	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U6	156-0374-00		MICROCIRCUIT,DI:QUAD 2-INPUT NOR BUFFER	01295	SN7428N
U7	156-0084-00		MICROCIRCUIT,DI:SYNCHRONOUS DECADE COUNTER	07263	9310DC
U8	156-0058-00		MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U9	156-0255-00		MICROCIRCUIT,DI:QUAD 2-INPUT NOR GATE	18324	SP380A
U10	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U11	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U12	156-0047-00		MICROCIRCUIT,DI:3-INPUT NAND GATE	01295	SN7410N
U13	156-0150-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND BUFF	01295	SN7437N

Ckt No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Name & Description	Mfr Code	Mfr Part Number
A7	670-3505-00		CKT BOARD ASSY:PROGRAMMER	80009	670-3505-00
C1	290-0114-00		CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C2	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C3	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C4	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C5	290-0536-00		CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
CR1	152-0141-02		SEMICOND DEVICE:SILICON,30V,150MA	07910	CD8220
R1	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R2	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R3	315-0113-00		RES.,FXD,COMP:11K OHM,5%,0.25W	01121	CB1135
R4	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R5	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R6	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
U1	156-0081-00		MICROCIRCUIT,LI:SGL RETRIGGERABLE MV	07263	9601PC
U2	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U3	156-0221-00		MICROCIRCUIT,DI:QUAD LATCH	01295	SN74175N
U4	156-0039-00		MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U5	156-0047-00		MICROCIRCUIT,DI:3-INPUT NAND GATE	01295	SN7410N
U6	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U7	156-0043-00		MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U8	156-0043-00		MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U9	156-0221-00		MICROCIRCUIT,DI:QUAD LATCH	01295	SN74175N
U10	156-0039-00		MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U11	156-0058-00		MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U12	156-0041-00		MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U13	156-0186-00		MICROCIRCUIT,DI:QUAD 2-INPUT NAND GATE	01295	SN7403N
U14	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U15	156-0221-00		MICROCIRCUIT,DI:QUAD LATCH	01295	SN74175N
U16	156-0039-00		MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U17	156-0186-00		MICROCIRCUIT,DI:QUAD 2-INPUT NAND GATE	01295	SN7403N
U18	156-0163-00		MICROCIRCUIT,DI:TRIPLE 3-INPUT POS AND GATE	18324	N7411A
U19	156-0034-00		MICROCIRCUIT,DI:DUAL 4-INPUT NAND GATE	01295	SN7420N
U20	156-0058-00		MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U21	156-0221-00		MICROCIRCUIT,DI:QUAD LATCH	01295	SN74175N
U22	156-0144-00		MICROCIRCUIT,DI:3-INPUT POS NAND GATE	01295	SN7412N
U23	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U24	156-0039-00		MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
A8	670-3502-00		CKT BOARD ASSY:OFF SCALE	80009	670-3502-00
C1	290-0114-00		CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C2	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C3	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C4	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
R1	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R2	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R3	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
U1	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U2	156-0037-00		MICROCIRCUIT,DI:2-INPUT +AND/OR/INVERT GATE	01295	SN7451N
U3	156-0058-00		MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P

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Ckt No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Name & Description	Mfr Code	Mfr Part Number
U4	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U5	156-0043-00		MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U6	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U7	156-0087-00		MICROCIRCUIT,DI:4-BIT BINARY FULL ADDER	01295	SN7483N
U8	156-0043-00		MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U9	156-0221-00		MICROCIRCUIT,DI:QUAD LATCH	01295	SN74175N
U10	156-0171-00		MICROCIRCUIT,LI:QUAD 2-INPUT POS OR GATE	01295	SN7432N
U11	156-0125-00		MICROCIRCUIT,LI:QUAD 2-INPUT POS NAND BFR	01295	SN74157N
U12	156-0221-00		MICROCIRCUIT,DI:QUAD LATCH	01295	SN74175N
U13	156-0125-00		MICROCIRCUIT,LI:QUAD 2-INPUT POS NAND BFR	01295	SN74157N
U14	156-0222-00		MICROCIRCUIT,DI:HEX.LATCH	01295	SN74174N
U15	156-0039-00		MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U16	156-0145-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND BUFF	01295	SN7438N
U17	156-0222-00		MICROCIRCUIT,DI:HEX.LATCH	01295	SN74174N
U18	156-0058-00		MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U19	156-0192-00		MICROCIRCUIT,DI:64-BIT READ/WHITE MEMORY	27014	DM/SN7489
U20	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U21	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
A9	670-3454-00		CKT BOARD ASSY:DATA	80009	670-3454-00
C1	290-0114-00		CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C2	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C3	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C4	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
R1	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R2	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R3	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R4	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R5	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R6	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R7	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R8	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
U1	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U2	156-0087-00		MICROCIRCUIT,DI:4-BIT BINARY FULL ADDER	01295	SN7483N
U3	156-0248-00		MICROCIRCUIT,DI:FULLY SYNC BINARY COUNTER	01295	SN74163N
U4	156-0248-00		MICROCIRCUIT,DI:FULLY SYNC BINARY COUNTER	01295	SN74163N
U5	156-0248-00		MICROCIRCUIT,DI:FULLY SYNC BINARY COUNTER	01295	SN74163N
U6	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U7	156-0367-00		MICROCIRCUIT,DI:4-BIT PAR-ACS SHIFT RGTR	18324	N74195B
U8	156-0367-00		MICROCIRCUIT,DI:4-BIT PAR-ACS SHIFT RGTR	18324	N74195B
U9	156-0367-00		MICROCIRCUIT,DI:4-BIT PAR-ACS SHIFT RGTR	18324	N74195B
U10	156-0367-00		MICROCIRCUIT,DI:4-BIT PAR-ACS SHIFT RGTR	18324	N74195B
U11	156-0041-00		MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U12	156-0041-00		MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U13	156-0041-00		MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U14	156-0192-00		MICROCIRCUIT,DI:64-BIT READ/WHITE MEMORY	27014	DM/SN7489
U15	156-0062-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS EXCL GATE	04713	MC7486P

Ckt No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Name & Description	Mfr Code	Mfr Part Number
A10	670-3494-00		CKT BOARD ASSY:AXIS	80009	670-3494-00
C1	290-0114-00		CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C2	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C3	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C4	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
R1	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
U1	156-0037-00		MICROCIRCUIT,DI:2-INPUT +AND/OR/INVERT GATE	01295	SN7451N
U2	156-0031-00		MICROCIRCUIT,DI:2-INPUT AND/OR/INVERT GATE	01295	SN7454N
U3	156-0031-00		MICROCIRCUIT,DI:2-INPUT AND/OR/INVERT GATE	01295	SN7454N
U4	156-0043-00		MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U6	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U7	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U8	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U9	156-0058-00		MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U11	156-0043-00		MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U12	156-0039-00		MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U13	156-0039-00		MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U14	156-0037-00		MICROCIRCUIT,DI:2-INPUT +AND/OR/INVERT GATE	01295	SN7451N
U16	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U17	156-0058-00		MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U18	156-0039-00		MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U19	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
A11	670-3421-00		CKT BOARD ASSY:DATA CONVERTER	80009	670-3421-00
C1	290-0114-00		CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C2	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C3	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C4	283-0111-00		CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
CR1	152-0075-00		SEMICONV DEVICE:GE,25V,40MA	72982	ED48
CR2	152-0075-00		SEMICONV DEVICE:GE,25V,40MA	72982	ED48
R1	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R2	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R3	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R4	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R5	315-0102-00		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R6	315-0471-00		RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
U1	156-0039-00		MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U2	156-0043-00		MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U3	156-0087-00		MICROCIRCUIT,DI:4-BIT BINARY FULL ADDER	01295	SN7483N
U4	156-0087-00		MICROCIRCUIT,DI:4-BIT BINARY FULL ADDER	01295	SN7483N
U5	156-0087-00		MICROCIRCUIT,DI:4-BIT BINARY FULL ADDER	01295	SN7483N
U6	156-0043-00		MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U7	156-0367-00		MICROCIRCUIT,DI:4-BIT PAR-ACS SHIFT RGTR	18324	N74195B
U8	156-0367-00		MICROCIRCUIT,DI:4-BIT PAR-ACS SHIFT RGTR	18324	N74195B
U9	156-0367-00		MICROCIRCUIT,DI:4-BIT PAR-ACS SHIFT RGTR	18324	N74195B
U10	156-0367-00		MICROCIRCUIT,DI:4-BIT PAR-ACS SHIFT RGTR	18324	N74195B
U11	156-0039-00		MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P

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Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
U12	156-0192-00			MICROCIRCUIT,DI:64-BIT READ/WHITE MEMORY	27014	DM/SN7489
U13	156-0163-00			MICROCIRCUIT,DI:TRIPLE 3-INPUT POS NAND GATE	18324	N7411A
U14	156-0186-00			MICROCIRCUIT,DI:QUAD 2-INPUT NAND	01295	SN7403N
U15	156-0047-00			MICROCIRCUIT,DI:3-INPUT NAND GATE	01295	SN7410N
A12	670-3457-00			CKT BOARD ASSY:CAL INTERFACE NO.2	80009	670-3457-00
C1	290-0114-00			CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C2	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C3	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C4	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
R1	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R3	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
U1	156-0171-00			MICROCIRCUIT,LI:QUAD 2-INPUT POS OR GATE	01295	SN7432N
U2	156-0030-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U3	156-0218-00			MICROCIRCUIT,DI:8-BIT ADDRESSABLE LATCH	07263	9334DC
U4	156-0098-00			MICROCIRCUIT,DI:DUAL 4 LINE-1 LINE DATA SEL	01295	SN74153N
U5	156-0497-00			MICROCIRCUIT,DI:10-BIT SHIFT REGISTER	18324	N8273B
U6	156-0163-00			MICROCIRCUIT,DI:TRIPLE 3-INPUT POS AND GATE	18324	N7411A
U7	156-0498-00			MICROCIRCUIT,DI:10-BIT SHIFT REGISTER	18324	N8273B
U8	156-0039-00			MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U9	156-0058-00			MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U10	156-0129-00			MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U11	156-0171-00			MICROCIRCUIT,LI:QUAD 2-INPUT POS OR GATE	01295	SN7432N
U12	156-0129-00			MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U13	156-0203-00			MICROCIRCUIT,DI:TRIPLE 3-INPUT NOR GATE	56289	US7418A
U14	156-0129-00			MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U15	156-0171-00			MICROCIRCUIT,LI:QUAD 2-INPUT POS OR GATE	01295	SN7432N
A13	670-3456-00	B010100	B019999	CKT BOARD ASSY:CAL INTERFACE NO.1	80009	670-3456-00
	670-3456-01	B020000		CKT BOARD ASSY:CAL INTERFACE NO.1	80009	670-3456-01
C1	290-0114-00			CAP.,FXD,ELCTLT:47UF,20%,6V	56289	150D476X0006B2
C2	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C3	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C4	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C5	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C6	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C7	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C8	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
R1	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R2	315-0121-00	B010000	B020200	RES.,FXD,COMP:120 OHM,5%,0.25W	01121	CB1215
R2	315-0102-00	B020201		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R3	315-0181-00	B010000	B020200	RES.,FXD,COMP:180 OHM,5%,0.25W	01121	CB1815
R3	315-0102-00	B020201		RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
U1	156-0058-00			MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P
U2	156-0061-00			MICROCIRCUIT,DI:SGL,BCD TO DEC DECODER	01295	SN7442N
U3	156-0218-00			MICROCIRCUIT,DI:8-BIT ADDRESSABLE LATCH	07263	9334DC
U4	156-0043-00			MICROCIRCUIT DI:2-INPUT NOR GATE	01295	SN7402N
U5	156-0041-00			MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U6	156-0455-00			MICROCIRCUIT,DI:HEX.BUS VEC	27014	DM8837N
U8	156-0098-00			MICROCIRCUIT,DI:DUAL 4 LINE-1 LINE DATA SEL	01295	SN74153N
U9	156-0145-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND BUFF	01295	SN7438N
U11	156-0455-00			MICROCIRCUIT,DI:HEX.BUS VEC	27014	DM8837N
U12	156-0058-00			MICROCIRCUIT,DI:HEX INVERTER	04713	MC7404P

Ckt No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Name & Description	Mfr Code	Mfr Part Number
U13	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
U14	156-0062-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS EXCL GATE	04713	MC7486P
U15	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U16	156-0455-00		MICROCIRCUIT,DI:HEX.BUS VEC	27014	DM8837N
U17	156-0061-00		MICROCIRCUIT,DI:SGL,BCD TO DEC DECODER	01295	SN7442N
U18	156-0030-00		MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U19	156-0171-00		MICROCIRCUIT,LI:QUAD 2-INPUT POS OR GATE	01295	SN7432N
U20	156-0129-00		MICROCIRCUIT,DI:QUAD 2-INPUT GATE	01295	SN7408N
A17	670-3629-00		CKT BOARD ASSY:PANEL SWITCH	80009	670-3629-00
S1030	260-1666-00		SWITCH,PUSH:XY LOAD	71590	2KAB010000-674
S1032	260-1665-00		SWITCH,PUSH:	71590	2KAA010000-673
S1034	260-1667-00		SWITCH,LEVER:	80009	260-1667-00
S1035	260-1667-00		SWITCH,PUSH:	80009	260-1667-00
S1036	260-1665-00		SWITCH,PUSH:	71590	2KAA010000-673
S1040	260-1666-00		SWITCH,PUSH:	71590	2KAB010000-674
S1041	260-1666-00		SWITCH,PUSH:	71590	2KAB010000-674
CHASSIS					
B1001	119-0492-00		FAN,AXIAL:115V	32284	SP3A2
B1010	147-0040-00		MOTOR,DC:0.125 INCH SHAFT	72421	20-2223D200F6
B1020	147-0040-00		MOTOR,DC:	72421	20-2223D200F6
C1003	290-0710-00		CAP.,FXD,ELCTLT:50,000UF,10%,15V	90201	CGS503U015V4C
C1004	290-0709-00		CAP.,FXD,ELCTLT:6000UF,10%,40V	90201	CG5602U050R4
CR1003	152-0518-00		SEMICOND DEVICE:SILICON,50V,27A	04713	MDA990-1
CR1004	152-0535-00		SEMICOND DEVICE:SILICON,100V,12A	04713	MDA980-2
DS1030	150-1001-00		LAMP,LED:RED,2V,100MA	28480	5082-4403
DS1032	150-1001-00		LAMP,LED:RED,2V,100MA	28480	5082-4403
F1001	159-0023-00		FUSE,CARTRIDGE:2A,250V,SLOW-BLOW	71400	MDX2
FL1000	119-0389-00		FILTER,RAD INT:115/230V,3A	05245	F1440
L1005	119-0485-00		SOLENOID,ELEC:45 DEG RIGHT	81840	H-2117-035
Q1010	151-0140-00		TRANSISTOR:SILICON,NPN	02735	36568
Q1020	151-0140-00		TRANSISTOR:SILICON,NPN	02735	36568
R1010	308-0768-00		RES.,FXD,WW:15 OHM,5%,30W	91637	HL24-15R00J
R1012	308-0768-00		RES.,FXD,WW:15 OHM,5%,30W	91637	HL24-15R00J
R1020	308-0768-00		RES.,FXD,WW:15 OHM,5%,30W	91637	HL24-15R00J
R1022	308-0768-00		RES.,FXD,WW:15 OHM,5%,30W	91637	HL24-15R00J
S1001	260-1179-00		SWITCH,TOGGLE:DPST,10A,250VAC	27193	8931K162
S1045	260-1309-00		SWITCH,PUSH:SPDT,5A,250VAC	01963	E63-10H
S1060	260-1683-00		SWITCH,PUSH:SPDT,0.1A,125VAC	01963	E63-10A
T1001	120-0928-00		XFMR,PWR STPDN:	80009	120-0928-00



# Section 5

## WIRING

This section contains an Index of Signal Names, Wire Lists, and Connector Diagrams. This section is to be used as a reference section when referring to the schematics, system diagrams, and System Description writeups.

The Index of Signal Names describes the signals in alphabetical order as they are found on the Mother Board and elsewhere in the plotter.

The wire lists show the origin of signals and all the connections that share common signals. The wire lists are organized by jack and pin numbers (connectors) on the Mother Board, and by plug numbers for connections to other than the Mother Board.

### INDEX OF SIGNAL NAMES

The following is an index of signal names that appear throughout the plotter circuitry. Any mnemonic signal name with a bar across the top ( $\overline{\phantom{x}}$ ) is true with a low level signal voltage. All others are true with a high level signal voltage.

AC and  $\overline{AC}$

Address compare. Used in the Calculator interface handshake routine indicating that the plotter has been addressed.

$\overline{ACCK}$

Accumulator clock. Used to load the arithmetic accumulator or multiply its contents by two. The arithmetic accumulator is on the Data card.

ACLD

Accumulator Load. When high, data is loaded in or out of the arithmetic accumulator using four  $\overline{ACCK}$  clock pulses. During T0 through T3, results of arithmetic are loaded into the arithmetic accumulator. During T4 through T7, accumulator contents are written into one of the data memories. When ACLD is low,  $\overline{ACCK}$  multiplies the contents of the arithmetic accumulator by two.

ACS

Accumulator sign. Low is positive data, high is two's complement or negative data.

AC1, AC2,  
AC4, AC8

The four parallel bit lines of the arithmetic accumulator information indicated by their binary weighting as hexadecimal digits.

AUCRYIN

Arithmetic Unit Carry Input. This signal provides the input carry information to the adder on the Data card. An initial carry, adding one to the data, is produced when  $\overline{GATE}$  is low.

AUCRYOUT

Arithmetic Unit Carry Output. This signal originates at the adder on the Data card. It also circulates the carry information through the Timing card.

$\overline{AXIS STP}$

Generated on the Axis Control card to enable the memory write operation, used to incrementally update the Delta Memory and Position Memory during the RUN cycle.

CAL 0

This signal is asserted when the exponent of incoming BCD data from the calculator interface is greater than 1 or less than -2.

## Wiring—4661 Service

CAL 1, CAL 2, CAL 4, CAL 8	These are the calculator interface data lines entering the BCD-to-Binary converter on the Data Converter card. They have a direct bit relationship to DIO1, DIO2, DIO4, and DIO8 unless CAL 0 is asserted.	ECP1	External clock phase 1 from the calculator that provides timing for the calculator interface circuits. It is responsible for retrieving data from the data lines (DIO1, DIO2, DIO4, and DIO8).
CHART ON	This signal is high when the electrostatic field is present to hold the chart paper to the plotting surface. It provides power to the oscillator that produces the electrostatic field.	EPC2	External clock phase 2 from the calculator that provides timing for the calculator interface circuits. It is responsible for determining when data is on the data lines (DIO1, DIO2, DIO4, and DIO8).
$\overline{CK}$	Plotter clock. A 1 MHz clock pulse originating on the Timing Board having a duty cycle of 25%, used to define the plotter T times. It is used primarily to strobe data onto numerous plotter data lines.	$\overline{EXTSHFT}$	Extra shift. When low, it allows $\overline{ACCK}$ to multiply the contents of the arithmetic accumulator by two to accomplish the full-scale mode of operation.
CK01	Plotter clock phase 1. A 1 MHz clock pulse, which is out of phase with $\overline{CK}$ and is used primarily to latch information from data lines during plotter T times.	FCHNEW	Fetch new data. When high, a register of the New Data Memory on the Data Converter card is addressed to fetch binary position information to be plotted.
$\overline{CLAC}$	Clear the Address Compare. When low, the AC signal used during the calculator interface handshake is caused to reset.	$\overline{FCH+WRT}$	Fetch or Write. $\overline{FCH+WRT}$ , when true, causes ACLD to go high. During T0, T1, T2, and T3, data is fetched, arithmetic is performed, and results are loaded into the arithmetic accumulator. When $\overline{FCH+WRT}$ is true during T4, T5, T6, and T7, contents of the arithmetic accumulator are written into either the Position or Delta Memory.
CONV	Indicates that the BCD-to-Binary conversion cycle on the Data Converter card is taking place.		
CONV2	Indicates the second half of the BCD-to-Binary conversion cycle on the Data Converter card.	FSTSTP	Fast Axis Stepping Pulse. The frequency of this signal, as wired into the plotter, is equal to RTSTP divided by 8. FSTSTP is used to clock the halfway counter on the Data card and also provides the stepping pulse used by the stepping motor on the fast axis.
DONE	Asserted by the Axis Control card upon completion of pen movement in both the X and Y axes. It signals the program RUN sequence to end.		
DIO1, DIO2, DIO4, DIO8	The BCD data lines from the calculator interface.	$\overline{GATE+1}$	Is used to gate an extra carry bit into the arithmetic unit for incrementing data or completing a two's complement of data.

$\overline{\text{GATE}}-1$	When low, the arithmetic unit subtracts one from the data arriving on the new data lines ( $\overline{\text{ND1}}$ , $\overline{\text{ND2}}$ , $\overline{\text{ND4}}$ , and $\overline{\text{ND8}}$ ) and places the result in the arithmetic accumulator.	$\text{MAN}+\text{INMV}$	Manual move or initial move. This signal is generated on the Program card.
$\text{GATEAC}$	When high it allows the contents of the arithmetic accumulator to be added to data entering on the new data lines ( $\overline{\text{ND1}}$ , $\overline{\text{ND2}}$ , $\overline{\text{ND4}}$ , and $\overline{\text{ND8}}$ ).	$\text{MANMV}$	Manual move.
$\text{INCK}$	A clock signal referenced to $\text{ECP1}$ , which loads the BCD-to-Binary converter on the Data Converter card with BCD information from the calculator interface.	$\text{MAP}$	A high on this line indicates a Position Memory address (PX or PY) when $\overline{\text{MEMSEL}}$ is activated.
$\text{JCONV}$	Generated by the calculator interface circuits to initiate BCD-to-Binary data conversion.	$\text{MAY}$	A high on this line indicates a Y register address for any data memory.
$\text{JOG SLW}$	Slow Manual Move. This signal is asserted by the Panel Interface circuits when a slow manual move is initiated.	$\text{MV}+\text{SLW}$	Equivalent to slow manual move.
$\text{JPEN}$	Pen activation command asserted as the result of remote instructions (33 and 34) from the calculator. With the $\overline{\text{PROGUP}}$ signal, it causes the pen to lift or lower.	$\overline{\text{MWRT}}$	Memory write. Asserted by the Timing card to write arithmetic accumulator data into the Position and Delta Memories during plotter times T4 to T7.
$\text{JPROG}$	Asserted upon the completion of BCD-to-Binary conversion of data pertaining to Y axis movement. $\text{JPROG}$ initiates the plotter program sequence which prepares the plotter circuitry for pen movement.	$\overline{\text{ND1}}, \overline{\text{ND2}}, \overline{\text{ND4}}, \overline{\text{ND8}}$	New data lines, activated by the data memories and forced constant logic, used as data input to the arithmetic unit on the Data card.
$\text{JRUN}$	Prepares the Axis Control card for the RUN sequence controlling pen movement.	$\overline{\text{OFFSCALE}}$	When low, it indicates that the pen is on or beyond the plotting boundary. It is generated on the Program card.
$\text{LDSW}$	Load switch. $\text{LDSW}$ is high when the LOAD switch is pressed in.	$\text{OFLN}$	Off line. It electrically disconnects the plotter from the calculator bus lines during a load or manual move operation.
$\text{LOAD}$	Load movement command that asserts X axis pen movement to the right until the X limit switch is closed.	$\overline{\text{PABSFCH}}$	Position fetch. When low, the Position Memory is addressed during a data fetch operation.
		$\text{PENDN}$	The pen down command generated on the Panel Interface card as the result of a calculator remote command (R33) or pressing the control panel PEN switch.

## Wiring—4661 Service

PENDN2	The enabled pen down command generated on the Program card, which is a modification of PENDN. PENDN2 is used by the Power Regulator Board to activate the pen solenoid.	P07	Seventh 10 $\mu$ s interval of the plotter program on the Program card.
PFCHY	Addresses the Y contents of the Position Memory or Delta Memory during an information fetch period, during plotter times T0 to T3.	P12	Twelfth 10 $\mu$ s interval of the plotter program on the Program card.
$\overline{\text{PLBY}}$	The plotter is busy, generated on the Panel Interface card.	$\overline{\text{QTCK}}$	Quotient clock. Occurs during T4CK01 in plotter program time P12 and in each of the sixteen cycles of the divide operation.
PLCO	Plot command initiated on the Data Converter card after the conversion of Y data to binary. It triggers the creation of JPROG, which starts the plotter program circuitry.	QT00	The most significant bit of the quotient register on the Velocity Generator card having a binary bit weighting of one.
PREAD	When high, it selects the Position Memory and Delta Memory. When low, the Zero Memory, New Data Memory, or off-scale position constants are selected.	QT15	The least significant bit of the quotient register on the Velocity Generator card having a binary bit weighting of $2^{-15}$ .
$\overline{\text{PROGUP}}$	Program up. When low and JPEN is asserted, the pen is caused to lift from the plotting surface. When $\overline{\text{PROGUP}}$ is high and JPEN is asserted, the pen is caused to lower to the plotting surface.	RMPDN	Ramp down. The signal from the halfway counter, when activated, causes the Velocity Generator circuitry to start decelerating the stepping motors.
PRZO	Program zero. It is created by decoding the set zero instruction (remote 30). PRZO causes the data in the Zero Memory to be replaced by data in the Position Memory.	RMPGATE	When High, it enables velocity acceleration/deceleration circuitry to update the velocity register on the Velocity Generator card. Its frequency determines, in part, the rate of acceleration and deceleration. RMPGATE originates on the Velocity Compensator card.
$\overline{\text{PWRT}}$	Write information into the Position or Delta Memory.	RMPSTP	Originates on the Velocity Generator Board to clock a counter on the Velocity Compensator card that generates RMPGATE.
PWRTY	Address Y information during a memory write time, plotter times T4 to T7.	$\overline{\text{RST}}$	The initial restart command, initiated by the Power Regulator when the instrument is first turned on. This signal activates the Initial Program on the Offscale card and other plotter initialization circuits.
$\overline{\text{P00}}$	First 10 $\mu$ s interval of the plotter program on the Program card.		

RTSTP	Shares the same frequency as RMPSTP. RTSTP is generated on the Velocity Generator card and used by the velocity Compensator card to generate FSTSTP, the fast axis stepping frequency.	STP2ND	Second step. A plotter control command asserted by the Axis Control card during the RUN cycle for updating the Position Memory.
RUN	Initiated by the Program card to allow the Axis Control card to assert program control over the stepping motors, the arithmetic unit, and other plotting circuitry. It is asserted the entire time a vector is being plotted and the stepping motor circuits are active.	$\overline{\text{SUB}}$	When low, the two's complement (binary negative) of data entering the arithmetic unit via $\overline{\text{ND1}}$ through $\overline{\text{ND8}}$ is added to the contents of the arithmetic accumulator data lines (AC1 through AC8) or zero, thus performing the subtraction function.
RUNEN	Run enable. RUNEN is generated on the Program card and is used by the Panel Interface circuits to generate a plotter busy signal.	SUM1, SUM2, SUM4, SUM8	The adder output lines originating on the Data card. These lines load information into the arithmetic accumulator and also provide input to offscale or plotter boundary comparison circuitry on the Offscale card.
$\overline{\text{SAMPLECK}}$	Clock signal for storing arithmetic accumulator sign information (ACS) in the delta sign register, a 3-bit shift register on the Data card.	SYNC	Generated by $\overline{\text{ESYNC}}$ from the calculator. It signals the first BCD digit of the data word appearing on the calculator interface data lines DIO1, DIO2, DIO4, and DIO8.
SELDW	Selected data word. SELDW goes high during the calculator data transfer signal, DW, if a valid remote device address for the plotter has been given.	TA, TB, TC, TD	Outputs of a plotter timing decade counter on the Timing card. TA, TB, TC, and TD have binary weightings of 1, 2, 4, and 8 respectively. They may be decoded to obtain specific 1 $\mu\text{s}$ intervals of plotter timing, T0 to T9, used as subdivisions of the larger 10 $\mu\text{s}$ intervals such as P00, P01, P02, etc.
SHIFT	Asserted when BCD data from the calculator interface is being shifted into the BCD-to-Binary converter. Data scaling with respect to exponent value also takes place at this time.	$\overline{\text{TKAG}}$	Goes low during P12 to load information into the halfway counter on the Data card.
SLWRTSTP	Is proportionately slower than RTSTP as determined by the contents of the quotient register. SLWRTSTP is generated on the Velocity Generator card and is used by the Velocity Compensator card to generate SLWSTP, the slow axis stepping frequency.	TV	Terminal Velocity. TV indicates that the velocity register on the Velocity Generator card had either reached or exceeded a predetermined terminal velocity constant.
STP1ST	First step. A plotter control command asserted by the Axis card during the RUN cycle for updating the Delta Memory.	TY	A clock signal related to the bit times used by the Velocity Generator and Velocity Compensator circuits for velocity data manipulation. Its frequency is twice that of TA.

## Wiring—4661 Service

T0, T1, T2, T9	(Calculator Interface) These timing signals indicate which BCD digit of the calculator data word is present on the calculator interface data lines DIO1, DIO2, DIO4, and DIO8. They are generated on the Calculator Interface #2 card using SYNC and ECP2. These T times are separate from the plotter timing signals T0 to T9, which are generated on the Timing Board.	$\overline{XBG}$	X big. A flag signal indicating that the X pen position is offscale in the big direction, the right plotting boundary.
		XCONV	X convert. A signal from the calculator interface circuits indicating that BCD-to-Binary conversion is to take place for X data.
		XDB	X delta big. Indicates DX, X axis movement, is bigger than DY, Y axis movement.
T4CK01	A plotter timing signal generated on the Timing card. It is equivalent to the CK01 clock occurring during plotter time T4.	XDN	X down. When high, the X axis pen movement is toward the left. PX, the X position register, is also counted down.
T9CK	A plotter timing signal generated on the Timing card. It is equivalent to the CK clock occurring during plotter time T9. The trailing edge of this pulse determines the transition between the 10 $\mu$ s plotter times such as P01, P02, P03, etc.	XDP	Indicates DX is positive.
		$\overline{XDUN}$	X done. Indicates that X axis movement has been completed.
$\overline{VCK}$	Velocity clock. Clock pulse used to latch the overflow carry from the digital integrator on the Velocity Generator card. It is also used to clock the RMPGATE counter on the Velocity Compensator card.	$\overline{XDUNCK}$	X done clock. Strobes a flip-flop on the Data card, to latch the sign of DX for creating $\overline{XDUN}$ .
VQ1, VQ2, VQ4, VQ8, VQ16, VQ32	Velocity Quotient. The six most significant bits of the quotient register on the Velocity Generator card, with the exception of QT00. VQ32 is the most significant bit and VQ1 is the least significant bit.	XFS	X full scale. X axis is in the full-scale mode, generated in the Panel Interface circuits.
		$\overline{XINITMV}$	X initial move. Goes low shortly after the power is turned on to force an X initial move to the right plotting boundary.
$\overline{V1}$	Velocity register output from the lower half of the velocity register on the Velocity Generator card.	XJOG	Manual move in the X axis as commanded by the Panel Interface circuits.
$\overline{V32}$	Velocity register output from the upper half of the velocity register on the Velocity Generator card.	XJOG+	Manual move in the X axis toward the right as commanded by the Panel Interface circuits.
XA	X absolute. A signal line indicating that the X data from the calculator references the origin or zero register.	XLIM	Panel Interface switch used during the initial zero setup indicating the X axis plotting limit on the right side of the plotting surface. It is also used to terminate a LOAD move.

XM	X data from the calculator is negative (minus).	$\overline{YDUN}$	Y done. Indicates that Y axis movement has completed.
XMV	X move, generated on the Axis Control card as the result of a command requiring X axis movement.	$\overline{YDUNCK}$	Y done clock. Strokes a flip-flop on the Data card, to latch the sign of DY for creating $\overline{YDUN}$ .
$\overline{XSM}$	X small. Indicates that the X position is offscale in the small direction, the left plotting boundary.	YFS	Y full scale. Y axis is in the full-scale mode, generated in the Panel Interface circuits.
XSTP	The stepping pulse used by the X axis stepping motor.	$\overline{YINITMV}$	Y initial move. Goes low soon after the plotter is turned on to force a Y initial move to the bottom plotting boundary.
$\overline{XSTP1ST}$	Generated 10 $\mu$ s prior to XSTP. It causes the DX register of Delta Memory to be decreased by one.	YJOG	Manual move in the Y axis as commanded by the Panel Interface circuits.
$\overline{XSTP2ND}$	Concurrent with XSTP. When XSTP is high, $\overline{XSTP2ND}$ is low. It causes the PX register of the position memory to be updated by one.	YJOG+	Manual move in the Y axis, to the rear, as commanded by the Panel Interface circuits.
XVC1, XVC2, XVC4, XVC8, XVC16, XVC32	The six most significant bits of X axis pen velocity used to provide voltage compensation to the X axis stepping motor.	YLIM	Panel Interface switch, used during the initial zero setup, indicates the Y axis plotting limit at the bottom of the plotting surface. To be activated the pen must be at the right front corner of the plotting surface.
YA	Y absolute. A signal line indicating that the Y data from the calculator references the origin or zero register.	YM	Y minus. Y data from the calculator is negative (minus).
$\overline{YBG}$	Y big. A flag signal indicating that the Y pen position is offscale in the big direction, the top plotting boundary.	YMFF	Y move flip-flop. Originates in the calculator interface circuits upon the decoding of a Y data command. It is used to initiate the plotter program circuits for pen movement upon the completion of BCD-to-Binary data conversion.
YDB	Y delta big. Indicates DY, Y axis movement, is bigger than DX, X axis movement.	YMV	Y move, generated on the Axis Control card as the result of a command requiring Y axis movement.
YDM	Indicates DY is negative (minus).	$\overline{YSM}$	Y small. Indicates that the Y position is offscale in the small direction, the bottom plotting boundary.
YDN	Y down. When high, the Y axis pen movement is toward the front. DY, the Y position register is also counted down.		

## Wiring—4641 Service

YSTP	The stepping pulse used by the Y axis stepping motor. YSTP is generated on the Axis Control card.	$\overline{\text{ZROFF1}}$	Goes low for 30 $\mu\text{s}$ during a set zero command. It addresses the Position Memory during a memory fetch time and addresses the Zero Memory during a memory write time. In conjunction with $\overline{\text{ZRO2}}$ it causes the Zero Memory to acquire the contents of the Position Memory.
$\overline{\text{YSTP1ST}}$	Generated 10 $\mu\text{s}$ prior to YSTP. It causes the DY register of the Delta Memory to be decreased by one.	$\overline{\text{ZRO2}}$	Goes low for 10 $\mu\text{s}$ during a set zero command to address the Y data in the Position Memory and Zero Memory. $\overline{\text{ZRO2}}$ and $\overline{\text{ZROFF1}}$ originate on the Panel Interface card.
$\overline{\text{YSTP2ND}}$	Concurrent with YSTP. When YSTP is high, $\overline{\text{YSTP2ND}}$ is low. It causes the PY register of the Position Memory to be updated by one.	$\overline{\text{1STABS}}$	First absolute. Goes low during the initial program cycle on the Off-scale card to address the Position Memory for loading initial position values.
YVC1, YVC2, YVC4, YVC8, YVC16, YVC32	The six most significant bits of Y axis pen velocity used to provide voltage compensation to the Y axis stepping motor.	$\overline{\text{1STABSY}}$	First absolute Y. The trailing edge of this first absolute Y signal clears the initial busy flip-flop located on the Program card.
$\overline{\text{ZMEMSEL}}$	Goes low when the Zero Memory has been selected or when initial position and off-scale constants are entered on the new data lines $\overline{\text{ND1}}$ , $\overline{\text{ND2}}$ , $\overline{\text{ND4}}$ , and $\overline{\text{ND8}}$ .	$\overline{\text{1STY}}$	First Y. Goes low during the initial program cycle on the Offscale card to address the Y data contents of the Zero Memory and the Position Memory.

## OTHER SIGNALS

These signals are used on the schematics indicated and never reach the Mother Board to be transferred to another circuit card.

### Axis Control

X MAN MV	This signal indicates a manual move on the X axis is taking place; resulting from the LOAD move command, the Initial Program $\overline{\text{XINITMV}}$ signal, and by activating the manual pen positioning switches, which issue JOG commands for horizontal movement.
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YMANMV	This signal indicates a manual move on the Y axis is taking place; resulting from the Initial Program $\overline{\text{YINITMV}}$ signal, and by activating the manual pen positioning switches which issue JOG commands for vertical movement.
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### Calculator Interface #1

$\overline{\text{AVS}}$	Address Valid Strobe. It is sent by the calculator to the plotter to indicate a valid remote command is on the interface address lines (UD1, UD2, UD4, UD8, and TD1, TD2, TD4, and TD8).
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$\overline{\text{DCLOW}}$	This signal is initiated by the calculator when the power to the calculator is turned on. It is used as a master reset to initialize logic circuits at power up.
$\overline{\text{DW}}$	Data Word. This signal goes low and remains low while the calculator is sending a data word containing 14 4-bit characters on the data I/O Lines (DI01, DI02, DI04, and DI08).
TD1, TD2, TD4, TD8.	These are the data lines from the calculator over which the tens digit of the remote command is sent to the plotter. The numbers in the mnemonics indicate the binary bit weighting of the BCD digit.
UD1, UD2, UD4, UD8.	These are the data lines from the calculator over which the units digit of the remote command is sent to the plotter. The numbers in the mnemonics indicate the binary bit weighting of the BCD digit.

#### Calculator Interface #2

LO EXP	The exponent of calculator data is negative.
--------	--

HI EXP	The exponent of calculator data is greater than 2.
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#### Panel Interface

$\overline{\text{BUSY}}$	This is the general plotter busy signal used to inhibit keyboard activity. It generally lasts one second longer than $\overline{\text{PLBY}}$ , the plotter busy signal used by the Calculator Interface.
DB	Debounce. This signal goes high when the debounce logic of the Panel Interface circuitry is activated as the result of pressing the PEN switch, the SET ZERO switch, or the LOAD switch.
DEBOUNCE	Debounce. See DB.
JOG+X	Manual Move to the right.
JOG-X	Manual Move to the left.
JOG+Y	Manual Move toward the rear.
JOG-Y	Manual Move toward the front.
J SLOW	Slow manual move.

### WIRE LISTS

The majority of the wiring in the 4661 Digital X-Y Plotter is contained within the Mother Board. The jacks into which the plotter circuit cards are inserted are illustrated by Fig. 5-1. Fig. 5-2 gives the pin locations used by the jacks on the Mother Board. The wire list tables are in sequential order by jack numbers as they appear on the Mother Board (Table 5-1). Asterisks in the wire list tables indicate the pins where signals originate.

The calculator signals are made available to the plotter via the I/O Board (Fig. 5-3). Signals which appear at the calculator interface I/O ports are tabulated in Fig. 5-4. Those signals marked with an asterisk in Fig. 5-4 are used in the plotter circuitry. For complete description of all interface signals, refer to the 21 AND 31 CALCULATOR INTERFACING INFORMATION manual, Tektronix Part No. 070-1695-00.

TABLE 5-1  
BOARD ORDER

J1	Power Supply or Power Regulator	①
J2	X Step Drive	②
J3	Velocity Compensator	③
J4	Velocity Generator	④
J5	Panel Interface	⑤
J6	Timing	⑥
J7	Program	⑦
J8	Offscale	⑧
J9	Data	⑨
J10	Axis Control	⑩
J11	Data Converter	⑪
J12	Calculator Interface #2	⑫
J13	Calculator Interface #1	⑬
J14	Y Step Drive	⑭

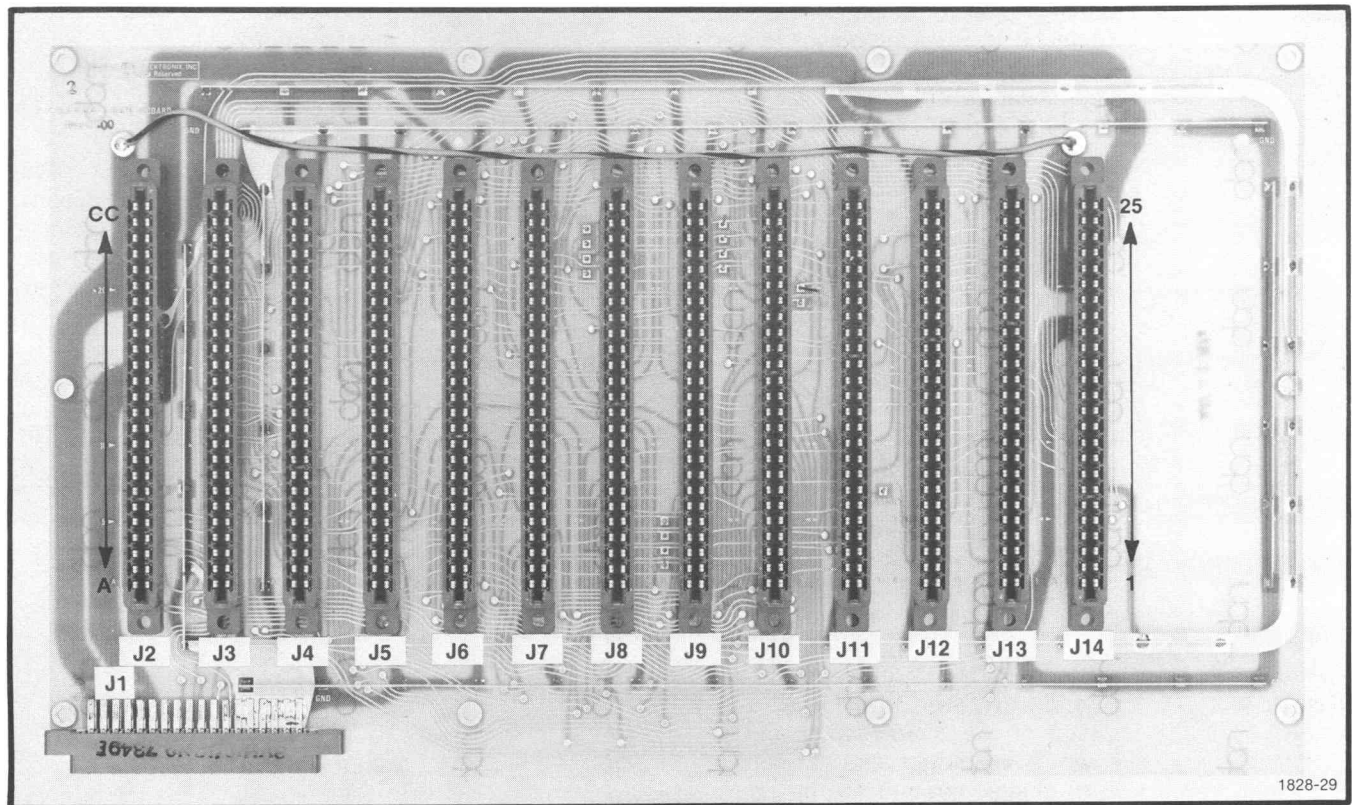


Fig. 5-1. Mother Board.

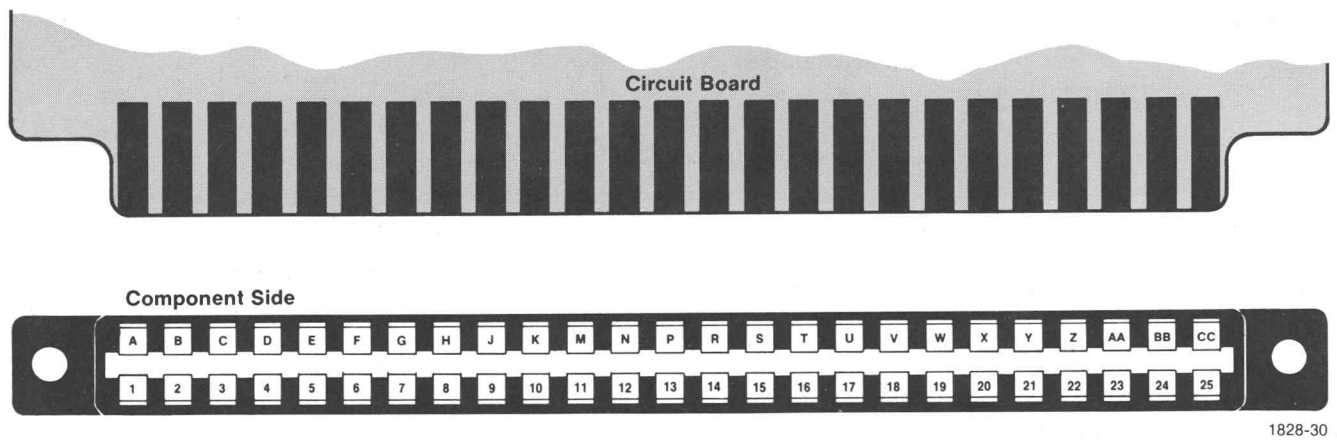


Fig. 5-2. Jacks on Mother Board.

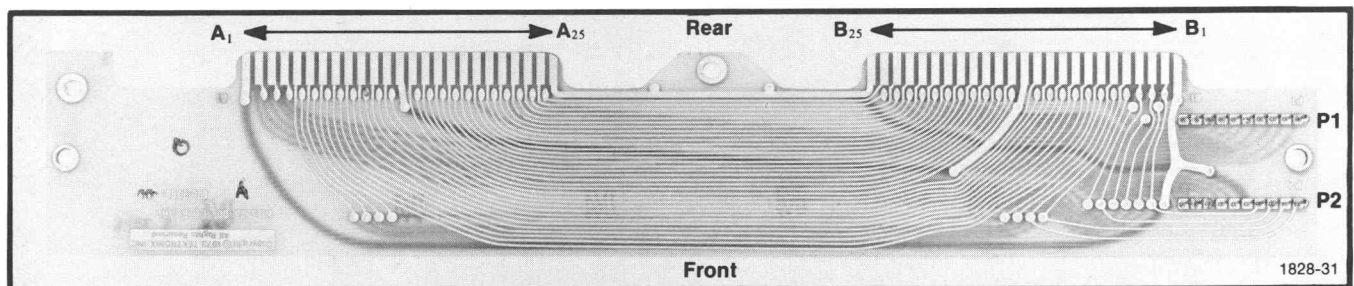
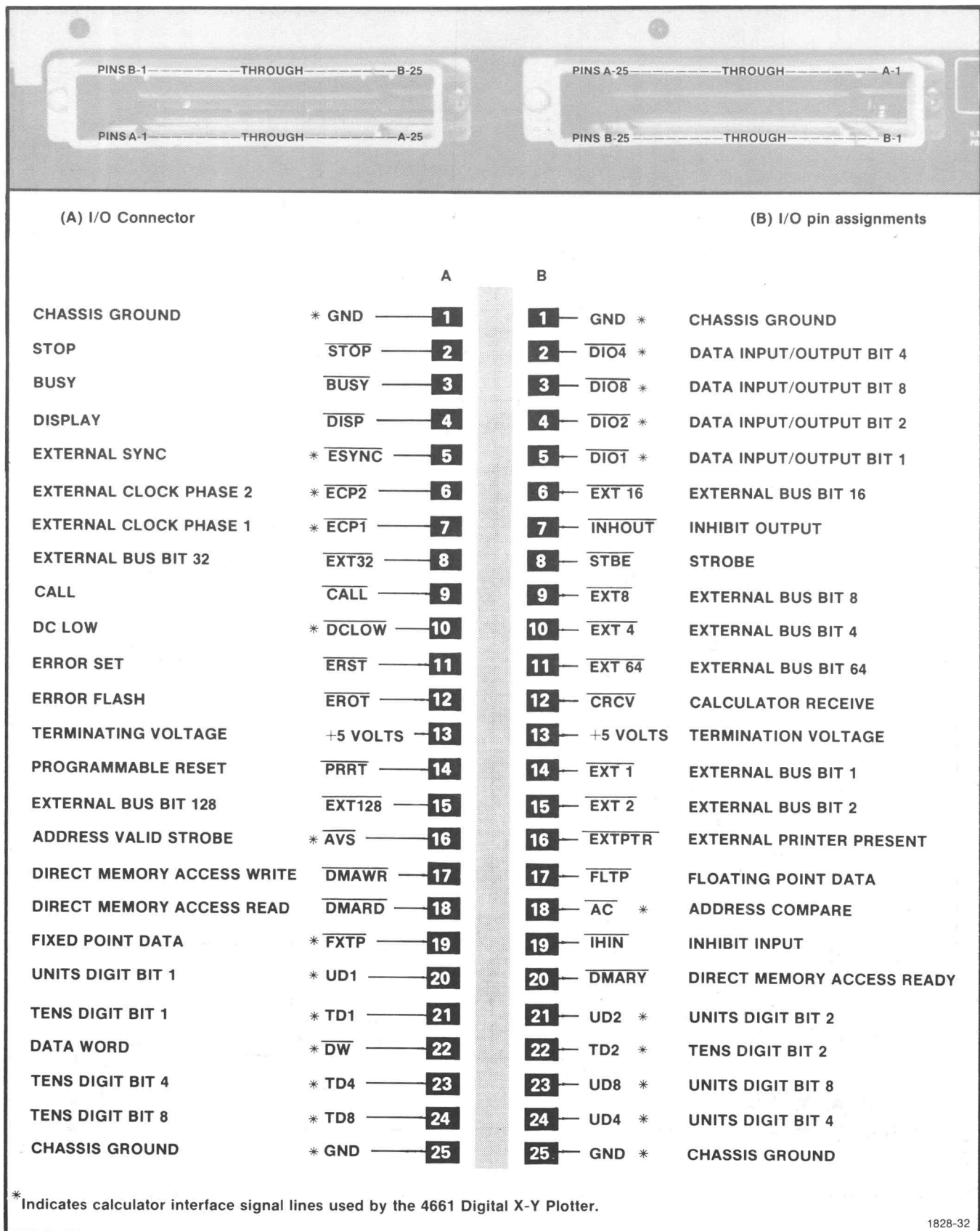
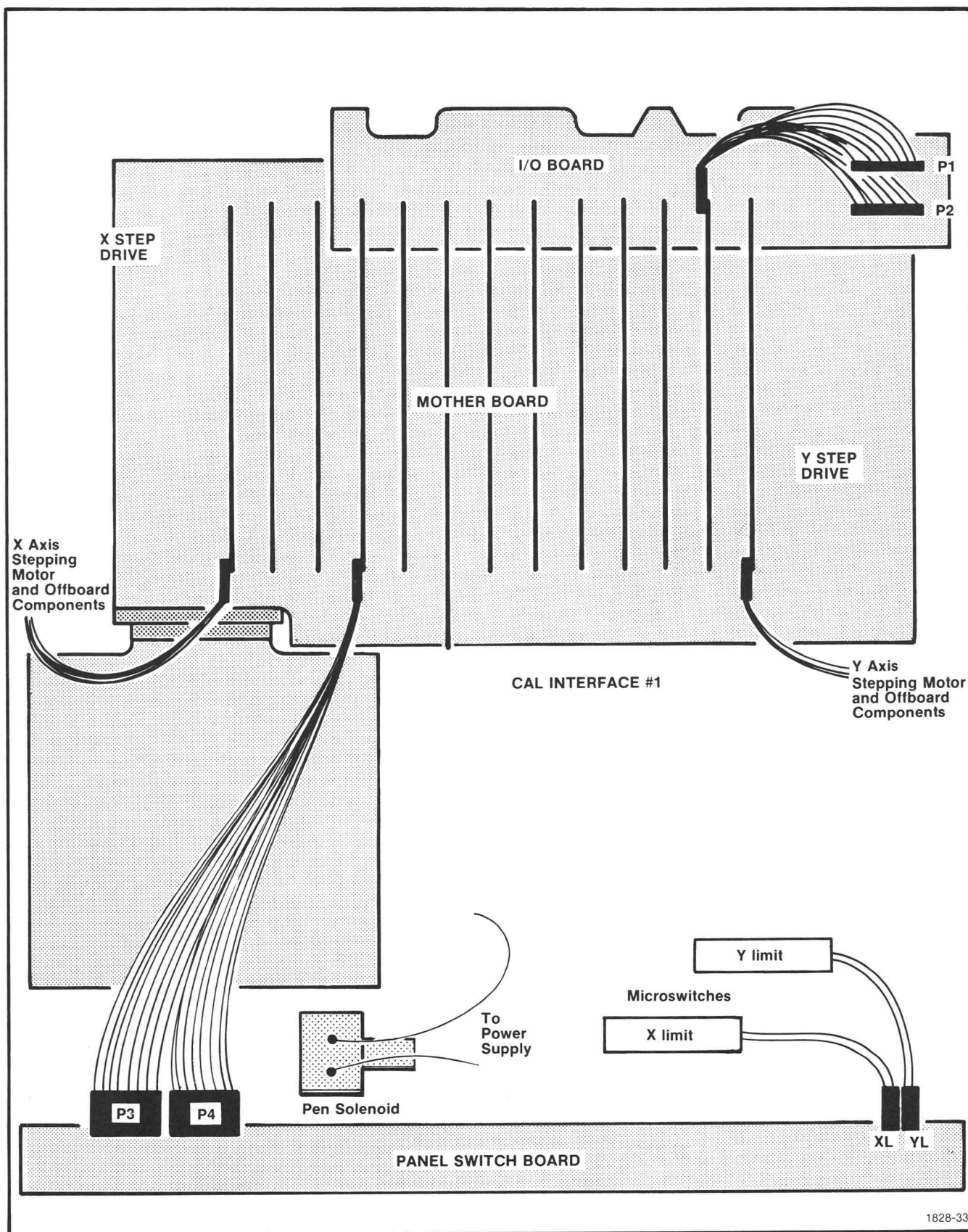


Fig. 5-3. I/O Board. For Calculator Interface connections.



1828-32

Fig. 5-4. Calculator-Plotter I/O Interface.



1828-33

Fig. 5-5. 4661 Plotter Wiring Diagram.

TABLE 5-2

**Mother Board (J1)  
Power Supply or Power Regulator**

Signal Name	Pin Number	Signal Name	Pin Number
+5 V dc	J1-1*	COM (cont)	J5-1
	J1-2*		J5-25
	J1-3*		J6-1
	J1-4*		J6-9
	J1-5*		J6-10
	J1-6*		J6-25
	J2-7		J7-1
	J3-A		J7-25
	J3-CC		J8-1
	J4-A		J8-25
	J4-CC		J9-1
	J5-A		J9-25
	J5-CC		J10-1
	J6-A		J10-25
	J6-CC		J11-1
	J7-A		J11-25
	J7-CC		J11-P
	J8-A		J12-1
	J8-CC		J12-25
	J9-A		J13-1
	J9-CC		J13-25
	J10-A		J14-U
	J10-CC		J14-V
	J11-A	$\overline{\text{RST}}$	J1-J*
	J11-CC		J5-U
	J12-A		J7-17
	J12-CC		J8-15
	J13-A		J10-W
	J13-CC		J11-W
	J14-7		J12-W
			J13-W
PENDN2	J1-7	+12 V dc	J1-K*
J7-C*	J5-B		
-SENSE	J1-8	+SENSE	J1-L†
COM	J1-A	CHART ON	J1-M
	J1-B		J5-2*
	J1-C	PWR GND	J1-P*
	J1-D		J1-R*
	J1-E		J1-S*
	J1-F		J2-23
	J2-U		J2-24
	J2-V		J2-25
	J3-1		J14-23
	J3-25		
	J4-1		
	J4-25		

\*Indicates the origin of the signal.

†Is tied to the +5 V dc supply via the Mother Board.

TABLE 5-2 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
PWR GND (cont)	J14-24 J14-25	+27 Vdc (cont)	J2-X
+27 V dc	J1-T*		J2-Y
	J1-U*		J2-Z
	J1-V*		J14-X
			J14-Y
			J14-Z

TABLE 5-3

**Mother Board (J2)  
X Step Drive**

Signal Name	Pin Number	Signal Name	Pin Number
XVC1	J2-1 J3-3*		J1-R J1-S
XVC2	J2-2 J3-2*	XDN	J2-J J10-18*
XVC32	J2-3 J3-B*	XSTP	J2-K J10-9*
XVC16	J2-4 J3-C*	T9CK	J2-L J5-V J6-X*
XVC8	J2-5 J3-D*		J11-X J14-L
XVC4	J2-6 J3-E*	COM	J2-U J2-V
+5 V dc	J2-7	+27 V dc	J2-X
PWR GND	J2-23 J2-24 J2-25 J1-P		J2-Y
			J2-Z
			J1-T
			J1-U J1-V

TABLE 5-4

**Mother Board (J3)  
Velocity Compensator**

Signal Name	Pin Number	Signal Name	Pin Number
COM	J3-1	YDB	J3-4
XVC2	J3-2*		J7-5
	J2-2		J9-H* J10-7
XVC1	J3-3* J2-1	QT00	J3-5 J4-E* J7-E

\*Indicates the origin of the signal.

TABLE 5-4 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
XMV	J3-6 J10-14*	TA	J3-21 J4-3 J6-3* J8-D J9-3 J11-3
YMV	J3-7 J10-12*		
$\overline{V32}$	J3-9 J4-P*		
VQ4	J3-10 J4-10*		
VQ2	J3-11 J4-11*	TB	J3-22 J4-4 J6-4* J8-E J9-4 J11-4
VQ1	J3-12 J4-12*		
VQ8	J3-13 J4-13*		
VQ16	J3-14 J4-14*		
VQ32	J3-15 J4-15*	YVC2	J3-23* J14-2
CK	J3-16 J4-16 J6-16* J8-T J11-16	YVC1	J3-24* J14-1
		COM	J3-25
		+5 V dc	J3-A
		XVC32	J3-B* J2-3
TY	J3-17 J4-18*	XVC16	J3-C* J2-4
		XVC8	J3-D* J2-5
$\overline{VCK}$	J3-18 J4-BB*	XVC4	J3-E* J2-6
MV+SLW	J3-19 J4-19*	$\overline{P00}$	J3-F J4-9 J7-9* J8-9 J9-9 J11-D
MAN+INMV	J3-20 J7-J J4-11* J12-2		
		FSTSTP	J3-L* J9-L J10-L

\*Indicates the origin of the signal.

TABLE 5-4 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
RTSTP	J3-M J4-M*	TD	J3-W J4-C J6-C* J11-C
SLWRTSTP	J3-N J4-N*		
LWSTP	J3-P* J10-R	TC	J3-X J4-B J6-B* J8-12 J11-B
$\overline{V1}$	J3-R* J4-Y*		
RMPGATE	J3-S* J4-S	YVC32	J3-Y* J14-3
CK01	J3-T J4-T J6-T* J8-U J11-T	YVC16	J3-Z* J14-4
RMPSTP	J3-U J4-24*	YVC8	J3-AA* J14-5
TV	J3-V J4-17*	YVC4	J3-BB* J14-6
		+5 V dc	J3-CC

TABLE 5-5

Mother Board (J4)  
Velocity Generator

Signal Name	Pin Number	Signal Name	Pin Number
COM	J4-1	$\overline{P00}$	J4-9 J3-F J7-9* J8-9 J9-9 J11-D
TA	J4-3 J3-21 J6-3* J8-D J9-3 J11-3	VQ4	J4-10* J3-10
TB	J4-4 J3-22 J6-4* J8-E J9-4 J11-4	VQ2	J4-11* J3-11
JRUN	J4-5 J7-F* J10-19	VQ1	J4-12* J3-12
		VQ8	J4-13* J3-13

\*Indicates the origin of the signal.

TABLE 5-5 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
VQ16	J4-14* J3-14	ACS	J4-F J9-F*
VQ32	J4-15* J3-15	$\overline{\text{QTCK}}$	J4-H J7-J*
CK	J4-16 J3-16 J6-16* J8-T J11-16	MAN+INMV	J4-J J3-20 J7-11* J12-2
TV	J4-17* J3-V	QT15	J4-K* J7-K
TY	J4-18* J3-17	P12	J4-L J7-M*
MV+SLW	J4-19* J3-19	RTSTP	J4-M* J3-M
T9	J4-21 J6-21* J7-X	SLWRTSTP	J4-N* J3-N
JOG SLW	J4-23 J5-23*	$\overline{\text{V32}}$	J4-P* J3-9
RMPSTP	J4-24* J3-U	RMPDN	J4-R J9-R*
COM	J4-25	RMPGATE	J4-S J3-S*
+5 V dc	J4-A	CK01	J4-T J3-T J6-T* J8-V J11-T
TC	J4-B J3-X J6-B* J8-12 J11-B	$\overline{\text{V1}}$	J4-Y* J3-R
TD	J4-C J3-W J6-C* J11-C	$\overline{\text{MV}}$	J4-Z J10-21*
QT00	J4-E* J3-5 J7-E	RUN	J4-AA J7-Y* J10-AA
		$\overline{\text{VCK}}$	J4-BB* J3-18
		+5 V dc	J4-CC

\*Indicates the origin of the signal.

TABLE 5-6

Mother Board (J5)  
Panel Interface

Signal Name	Pin Number	Signal Name	Pin Number
COM	J5-1	$\overline{\text{PROGUP}}$	J5-F J13-C*
CHART ON	J5-2* J1-M	YLIM	J5-H* J8-H
LDSW	J5-3* J12-3	XLIM	J5-J* J8-J
OFFSCALE	J5-4 J6-D J7-4*	XJOG+	J5-L* J10-11
ZRO2	J5-5* J6-Y	XJOG	J5-M* J10-V
$\overline{\text{ZROFF1}}$	J5-19* J6-23 J8-14 J9-19	YJOG+	J5-N* J10-N
$\overline{\text{PLBY}}$	J5-20* J13-P	YJOG	J5-P* J10-S
RUNEN	J5-21 J7-18* J11-18	XFS	J5-R* J7-R
$\overline{\text{JPEN}}$	J5-22 J13-B*	YFS	J5-S* J7-S
JOG SLW	J5-23* J4-23	$\overline{\text{RST}}$	J5-U J1-J* J7-17 J8-15 J10-W J11-W J12-W J13-W
PRZO	J5-24 J13-5*	T9CK	J5-V J2-L J6-X* J11-X J14-L
COM	J5-25	LOAD	J5-BB* J10-BB
+5 V dc	J5-A	+5 V dc	J5-CC
+12 V dc	J5-B J1-K*		
PENDN	J5-C* J5-D* J7-H		

\*Indicates the origin of the signal.

**TABLE 5-7**  
Mother Board (J6)  
Timing

Signal Name	Pin Number	Signal Name	Pin Number
COM	J6-1	1STABS	J6-19 J6-Z J8-X*
SUB	J6-2 J7-2* J9-2	T4CK01	J6-20* J7-W J10-5
TA	J6-3* J3-21 J4-3 J8-D J9-3 J11-3	T9	J6-21* J4-21 J7-X
TB	J6-4* J3-22 J4-4 J8-E J9-4 J11-4	PABSFCH	J6-22 J7-Z*
MAY	J6-5* J8-6 J9-5	ZROFF1	J6-23 J5-19* J8-14 J9-19
MAP	J6-6* J9-6	PFCHY	J6-24 J7-AA*
MEMSEL	J6-7* J9-7	COM	J6-25
MWRT	J6-8* J9-8	+5 V dc	J6-A
COM	J6-9 J6-10	TC	J6-B* J3-X J4-B J8-12 J11-B
FCH+WRT	J6-13* J8-N	TD	J6-C* J3-W J4-C J11-C
AUCRYIN	J6-15* J9-15	XSTP2ND	J6-E J8-B J10-E*
CK	J6-16* J3-16 J4-16 J8-T J11-16	YSTP2ND	J6-F J10-F*
		AXIS STP	J6-H J10-H*

\*Indicates the origin of the signal.

TABLE 5-7 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
GATE+1	J6-J J10-J*	CK	J6-V* J9-V
PWRT	J6-L J7-L*	T9CK	J6-X* J2-L J5-V J11-X J14-L
PREAD	J6-P J7-P*	ZRO2	J6-Y J5-5*
AUCRYOUT	J6-S J9-S*	1STABS	J6-Z J6-19 J8-X*
CK01	J6-T* J3-T J4-T J8-U J11-T	PWRTY	J6-BB J7 BB*
T9CK	J6-U* J7-U J8-Y J10-U	+5 V dc	J6-CC

**TABLE 5-8**  
Mother Board (J7)  
Program

Signal Name	Pin Number	Signal Name	Pin Number
COM	J7-1	FCHNEW	J7-7* J8-7 J11-F
SUB	J7-2* J6-2 J9-2	JPROG	J7-8 J11-7*
YSM	J7-3 J8-C* J10-10	P00	J7-9* J3-4 J4-9 J8-9 J9-9
OFFSCALE	J7-4 J5-4	TKΔG	J7-10* J9-10
YDB	J7-5 J3-4 J9-H* J10-7	MAN+INMV	J7-11* J3-20 J4-J J12-2
1STABSY	J7-6 J8-F*		

\*Indicates the origin of the signal.

TABLE 5-8 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
YDM	J7-12 J9-J* J10-8	+5 V dc	J7-A
		$\overline{\text{YSTP1ST}}$	J7-B J10-B*
GATEAC	J7-13* J9-14	PENDN2	J7-C* J1-7
$\overline{\text{YBG}}$	J7-14 J8-11* J10-T	YM	J7-D J13-2*
$\overline{\text{1STY}}$	J6-15 J8-S*	QT00	J7-E J3-5 J4-E*
XDB	J7-16 J9-M* J10-M	JRUN	J7-F* J4-5 J10-19
$\overline{\text{RST}}$	J7-17 J1-J* J5-U J8-15 J10-W J11-W J12-W J13-W	PENDN	J7-H J5-C* J5-D*
		$\overline{\text{QTCK}}$	J7-J* J4-H
RUNEN	J7-18* J5-21 J11-18	QT15	J7-K J4-K*
$\overline{\text{EXTSHFT}}$	J7-19* J8-W	$\overline{\text{PWRT}}$	J7-L* J6-L
$\overline{\text{SAMPLECK}}$	J7-20* J9-20	P12	J7-M* J4-L
MANMV	J7-21 J10-Y*	XM	J7-N J13-3*
$\overline{\text{ZMEMSEL}}$	J7-22 J8-22*	PREAD	J7-P* J6-P
P07	J7-23* J11-AA	XFS	J7-R J5-R*
DONE	J7-24 J10-X*	YFS	J7-S J5-S*
COM	J7-25	$\overline{\text{XBG}}$	J7-T J8-19* J10-24

\*Indicates the origin of the signal.

TABLE 5-8 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
T9CK	J7-U J6-U* J8-Y J10-U	RUN	J7-Y* J4-AA J10-AA
$\overline{\text{XSM}}$	J7-V J8-V* J10-20	$\overline{\text{PABSFCH}}$	J7-Z* J6-22
T4CK01	J7-W J6-20* J10-5	PFCHY	J7-AA* J6-24
T9	J7-X J4-21 J6-21*	PWRTY	J7-BB* J6-BB
		+5 V dc	J7-CC

TABLE 5-9

Mother Board (J8)  
Off-scale

Signal Name	Pin Number	Signal Name	Pin Number
COM	J8-1	$\overline{\text{P00}}$	J8-9 J4-9 J7-9* J9-9 J11-D J3-F
AC8	J8-2 J9-B		
AC4	J8-3 J9-C*	$\overline{\text{XINITMV}}$	J8-10* J10-23
AC2	J8-4 J9-D*	$\overline{\text{XBG}}$	J8-11* J7-14 J10-T
AC1	J8-5 J9-E*		
MAY	J8-6 J6-5* J9-5	TC	J8-12 J6-B* J3-X J4-B J11-B
FCHNEW	J8-7 J7-7* J11-F		
STP2ND	J8-8 J10-C*	$\overline{\text{ZROFF1}}$	J8-14 J5-19* J6-23 J9-19

\*Indicates the origin of the signal.

TABLE 5-9 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
RST	J8-15 J1-J* J5-U J7-17 J10-W J11-W J12-W J13-W	TA	J8-D J3-21 J4-3 J6-3* J9-3 J11-3
SUM2	J8-16 J9-16*	TB	J8-E J3-22 J4-4 J6-4* J9-4 J11-4
ACCK	J8-17* J9-17	1STABSY	J8-F* J7-6
ACLD	J8-18* J9-18	YLIM	J8-H J5-H*
XBG	J8-19* J7-T J10-24	XLIM	J8-J J5-J*
SUM4	J8-20 J9-X*	XA	J8-K J13-9*
ND1	J8-21* J9-21 J11-21*	YA	J8-L J13-10*
ZMEMSEL	J8-22* J7-22	FCH+WRT	J8-N J6-13*
SUM8	J8-23 J9-AA*	YINITMV	J8-P* J10-22
SUM1	J8-24 J9-BB*	1STY	J8-S* J7-15
COM	J8-25	CK	J8-T J3-16 J4-16 J6-16* J11-16
+5 V dc	J8-A	CK01	J8-U J3-T J4-T J6-T* J8-U J11-T
XSTP2ND	J8-B J6-E J10-E*		
YSM	J8-C* J10-10 J7-3		

\*Indicates the origin of the signal.

TABLE 5-9 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
XSM	J8-V* J7-V J10-20	ND2	J8-Z* J9-22 J11-22*
EXTSHFT	J8-W J7-19*	ND4	J8-AA* J9-23 J11-23*
1STABS	J8-X* J6-19 J6-Z	ND8	J8-BB* J9-24 J11-24*
T9CK	J8-Y J6-U* J7-U J10-U	+5 V dc	J8-CC

TABLE 5-10  
Mother Board (J9)  
Data

Signal Name	Pin Number	Signal Name	Pin Number
COM	J9-1	MEMSEL	J9-7 J6-7*
SUB	J9-2 J6-2 J7-2*	MWRT	J9-8 J6-8*
TA	J9-3 J3-21 J4-3 J6-3* J8-D J11-3	P00	J9-9 J3-F J4-9 J4-9* J8-9 J11-D
TB	J9-4 J3-22 J4-4 J6-4* J8-E J11-4	TKAG	J9-10 J7-10*
MAY	J9-5 J6-5* J8-6	XDUNCK	J9-11 J10-3*
MAP	J9-6 J6-6*	YDUNCK	J9-12 J10-4*
		GATE-1	J9-13 J10-13*
		GATEAC	J9-14 J7-13*

\*Indicates the origin of the signal.

TABLE 5-10 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
AUCRYIN	J9-15 J6-15*	YDB	J9-H* J10-7 J7-5 J3-4
SUM2	J9-16* J8-16	YDM	J9-J* J7-12 J10-8
ACK	J9-17 J8-17*	XDP	J9-K* J10-K
ACLD	J9-18 J8-18*	FSTSTP	J9-L J3-L* J10-L
SAMPLECK	J9-20 J7-20*	XDB	J9-M* J7-16 J10-M
ND1	J9-21 J8-21* J11-21*	XDUN	J9-P J10-P*
ND2	J9-22 J8-Z* J11-22*	RMPDN	J9-R* J4-R
ND4	J9-23 J8-AA J8-AA*	AUCRYOUT	J9-S* J6-S
ND8	J9-24 J8-BB* J11-24*	CK	J9-V J6-V*
COM	J9-25	SUM4	J9-X* J8-20
+5 V dc	J9-A	YDUN	J9-Z* J10-Z
AC8	J9-B* J8-2	SUM8	J9-AA* J8-23
AC4	J9-C* J8-3	SUM 1	J9-BB* J8-24
AC2	J9-D* J8-4	+5 V dc	J9-CC
AC1	J9-E* J8-5		
ACS	J9-F* J4-F		

\*Indicates the origin of the signal.

TABLE 5-11

Mother Board (J10)  
Axis Control

Signal Name	Pin Number	Signal Name	Pin Number
COM	J10-1	JRUN	J10-19 J4-5 J7-F*
XDUNCK	J10-3* J9-11	XSM	J10-20 J7-V J8-V*
YDUNCK	J10-4* J9-12	MV	J10-21* J4-Z
T4CK01	J10-5 J6-20* J7-W	YINITMV	J10-22 J8-P*
YDB	J10-7 J3-4 J7-5 J9-H*	XINITMV	J10-23 J8-10*
YDM	J10-8 J7-12 J9-J*	XBG	J10-24 J7-T J8-19*
XSTP	J10-9 J2-K*	COM	J10-25
YSM	J10-10 J7-3 J8-C*	+5 V dc	J10-A
XJOG+	J10-11 J5-L*	YSTP1ST	J10-B* J7-B
YMV	J10-12* J3-7	STP2ND	J10-C* J8-8
GATE-1	J10-13* J9-13	XSTP1ST	J10-D
XMV	J10-14* J3-6	XSTP2ND	J10-E* J6-E J8-B
YDN	J10-15* J14-J	YSTP2ND	J10-F* J6-F
YSTP	J10-16* J14-K	AXIS STP	J10-H* J6-H
XDN	J10-18* J2-J	GATE+1	J10-J* J7-J
		XDP	J10-K J9-K*

\*Indicates the origin of the signal.

TABLE 5-11 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
FSTSTP	J10-L J3-L* J9-L	XJOG	J10-V J5-M*
XDB	J10-M J7-16 J9-M*	RST	J10-W J1-J* J5-U J7-17 J8-15 J11-W J12-W J13-W
YJOG+	J10-N J5-N*	DONE	J10-X* J7-24
XDUN	J10-P J9-P*	MANMV	J10-Y* J7-21
SLWSTP	J10-R J3-P*	YDUN	J10-Z J9-Z*
YJOG	J10-S J5-P*	RUN	J10-AA J4-AA J7-Y*
YBG	J10-T J8-11* J7-14	LOAD	J10-BB J5-BB*
T9CK	J10-U J6-U* J7-U J8-Y	+5 V dc	J10-CC

TABLE 5-12

Mother Board (J11)  
Data Converter

Signal Name	Pin Number	Signal Name	Pin Number
COM	J11-1	XCONV	J11-6 J13-F*
TA	J11-3 J3-21 J4-3 J6-3* J8-D J9-3	JPROG	J11-7* J7-8
TB	J11-4 J3-22 J4-4 J6-4* J8-E J9-4	CAL4/DIO4	J11-8 J12-22 J13-22*
		CAL1	J11-10 J12-24*
		CAL2/DIO2	J11-15 J12-21 J13-21*

\*Indicates the origin of the signal.

TABLE 5-12 (cont)

Signal Name	Pin Number	Signal Name	Pin Number
CK	J11-16 J3-16 J4-16 J6-16* J8-T	P00	J11-D J3-F J4-9 J7-9* J8-9
CAL8	J11-17 J12-23*	FCHNEW	J11-F J8-7 J7-7*
RUNEN	J11-18 J5-21 J7-18*	INCK	J11-M J12-D*
CONV2	J11-19* J12-5	COM	J11-P
CONV	J11-20* J12-12	JCONV	J11-S J12-13*
ND1	J11-21 J8-21* J9-21	CK01	J11-T J3-T J4-T J6-T J8-U
ND2	J11-22 J8-Z* J9-22	RST	J11-W J1-J* J5-U J7-17 J8-15 J10-W J12-W J13-W
ND4	J11-23 J8-AA* J9-23	T9CK	J11-X J2-L J5-V J6-X* J14-L
ND8	J11-24 J8-BB* J9-24	PLCO	J11-Z J12-B*
COM	J11-25	P07	J11-AA J7-23*
+5 V dc	J11-A	+5 V dc	J11-CC
TC	J11-B J3-X J4-B J6-B* J8-12		
TD	J11-C J3-W J4-C J6-C		

\*Indicates the origin of the signal.

**TABLE 5-13**  
**Mother Board (J12)**  
**Cal Interface #2**

Signal Name	Pin Number	Signal Name	Pin Number
COM	J12-1	SHIFT	J12-E* J13-E
MAN+INMV	J12-2 J3-20 J4-J J7-11*	$\overline{\text{CLAC}}$	J12-H* J13-H
LDSW	J12-3 J5-3*	T0	J12-J* J13-J
VR	J12-4†	SELDW	J12-K J13-L*
CONV2	J12-5 J11-19*	AC	J12-L J13-K*
CONV	J12-12 J11-20*	T2	J12-M* J13-M
JCONV	J12-13* J11-S	T1	J12-N* J13-N
CAL0	J12-20* J13-20	OFLN	J12-T* J13-T
DIO2/CAL2	J12-21 J11-15 J13-21*	$\overline{\text{RST}}$	J12-W J1-J* J5-U J7-17 J8-15 J10-W J11-W J13-W
DIO4/CAL4	J12-22 J11-8 J13-22*	DIO1	J12-X* J13-X
CAL8	J12-23 J11-17*	DIO8	J12-Y* J13-Y
CAL1	J12-24 J11-10*	ECP2	J12-Z J13-Z*
COM	J12-25	SYNC	J12-AA J13-AA*
+5 V dc	J12-A	ECP1	J12-BB J13-BB*
PLCO	J12-B* J11-Z	+5 V dc	J12-CC
YMFF	J12-C J13-D*		
INCK	J12-D* J11-M		

\*Indicates the origin of the signal.

†VR is a logical pull-up line using a 1 k $\Omega$  resistor on the +5 V supply.

**TABLE 5-14**  
**Mother Board (J13)**  
**Cal Interface #1**

Signal Name	Pin Number	Signal Name	Pin Number
COM	J13-1	T0	J13-J J12-J*
YM	J13-2* J7-D	AC	J12-K* J12-L
XM	J13-3* J7-N	SELDW	J13-L* J12-K
PRZO	J13-5* J5-24	T2	J13-M J12-M*
XA	J13-9* J8-K	T1	J13-N J12-N*
YA	J13-10* J8-L	$\overline{\text{PLBY}}$	J13-P J5-20*
CAL0	J13-20 J12-20*	OFLN	J13-T J12-T*
DIO2/CAL2	J13-21* J11-15 J12-21	$\overline{\text{RST}}$	J13-W J1-1* J5-U J7-17 J8-15 J10-W J11-W J12-W
DIO4/CAL4	J13-22 J11-8 J12-22	DIO1	J13-X* J12-X
COM	J13-25	DIO8	J13-Y* J12-Y
+5 V dc	J13-A	ECP2	J13-Z* J12-Z
$\overline{\text{JPEN}}$	J13-B* J5-22	SYNC	J13-AA* J12-AA
$\overline{\text{PROGUP}}$	J13-C* J5-F	ECP1	J13-BB* J12-BB
YMFF	J13-D* J12-C	+5 V dc	J13-CC
SHIFT	J13-E J12-E*		
XCONV	J13-F* J11-6		
$\overline{\text{CLAC}}$	J13-H J12-H*		

\*Indicates the origin of the signal.

**TABLE 5-15**  
**Mother Board (J14)**  
**Y Step Drive**

Signal Name	Pin Number	Signal Name	Pin Number
YVC1	J14-1 J3-24*	PWR GND	J14-23 J14-24 J14-25 J1-P J1-R J1-S
YVC2	J14-2 J3-23*		
YVC32	J14-3 J3-Y*	YDN	J14-J J10-15*
YVC16	J14-4 J3-Z*	YSTP	J14-K J10-16*
YVC8	J14-5 J3-AA*	T9CK	J14-L J2-L J5-V J6-X* J11-X
YVC4	J14-6 J3-BB*	COM	J14-U J14-V
+5 V dc	J14-7	+27 V dc	J14-X J14-Y J14-Z

Tables 5-16 and 5-17 are for the cable connections between the I/O Board and the Calculator Interface #1 card. The cables at P1 and P2 make the calculator signals available to the plotter circuits and make plotter signals available to the calculator.

Tables 5-18 and 5-19 are for the cable connections between the Panel Switch Board and the Panel Interface card.

The plug colors follow the standard color code referenced to the last digit of the plug number, i.e., P1 is brown, P2 is red, P3 is orange, P4 is yellow, P5 is green, P6 is blue, P7 is violet, P8 is gray, P9 is white, and P10 is black. Not all colors are used in the plotter.

Two plugs on the Panel Switch Board may be labeled XL instead of P6 and YL instead of P7. XL, the two-pin connector from the X limit microswitch, is blue. YL, the two-pin connector from the Y limit microswitch, is violet. The 7-pin connectors from the stepping motors are black.

\*Indicates the origin of the signal.

**TABLE 5-16**  
**I/O Board (P1)**  
**Calculator Interface #1 (P1)**

Signal Name	Pin Number	Signal Name	Pin Number
TD8	P1-1	$\overline{\text{FXT}}\overline{\text{P}}$	P1-6
TD4	P1-2	$\overline{\text{AVS}}$	P1-7
$\overline{\text{DW}}$	P1-3	$\overline{\text{ECP}}\overline{1}$	P1-8
TD1	P1-4	DIO8	P1-9
UD1	P1-5	$\overline{\text{ECP}}\overline{2}$	P1-10

**TABLE 5-17**  
**I/O Board (P2)**  
**Calculator Interface #1 (P2)**

Signal Name	Pin Number	Signal Name	Pin Number
DIO1	P2-1	UD4	P2-6
$\overline{\text{ESYNC}}$	P2-2	UD8	P2-7
DIO2	P2-3	TD2	P2-8
DIO4	P2-4	UD2	P2-9
COM-GND	P2-5	$\overline{\text{AC}}$	P2-10

**TABLE 5-18**  
**Panel Interface (P3)**

Signal Name	Pin Number	Signal Name	Pin Number
$\overline{\text{PO}}$	P3-1	CHART ON	P3-6
VPO	P3-2	$\overline{\text{LDSW}}$	P3-7
$\overline{\text{BUSY}}$	P3-3	$\overline{\text{PEN}}$	P3-8
VBZ	P3-4	PZL	P3-9
+12 V dc	P3-5	JOG-X	P3-10

**TABLE 5-19**  
**Panel Interface (P4)**

Signal Name	Pin Number	Signal Name	Pin Number
J SLOW	P4-1	ZERO	P4-6
JOG+X	P4-2	$\overline{\text{XFS}}$	P4-7
LDSW	P4-3	$\overline{\text{YFS}}$	P4-8
JOG-Y	P4-4	XLIMIT	P4-9
JOG+Y	P4-5	YLIMIT	P4-10

# Section 6

## SYSTEM DESCRIPTION

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## HOW TO USE THE SYSTEM DESCRIPTION SECTION

### General

The System Description Section describes the electronics of the plotter in detail. Since circuitry on any of the boards within the plotter influences circuitry on other boards, this section is divided into functional areas for ease of understanding the fine points of plotter electronics.

A general discussion of plotter electronics starts with the System Description writeup. It uses the foldout system Diagram Fig. 7-2 and makes reference to other writeups in this section for detailed information.

### Troubleshooting Aids

This section is designed to assist the technician in troubleshooting the plotter electronics. Troubleshooting aids to be used with this section include the Wire List and Index of Signal Names; both are included in the Wiring Section of this manual.

In this section the System Writeup Abstracts give a brief description of each writeup; it is to be used as a rapid information locator aid. The Circuit Card Function writeup provides a key to locating writeups that describe in detail the circuitry found on each card. The System Description subsection is a general description of the plotter circuitry for a basic understanding of the electronics. The Detail Description subsection discusses plotter functions and circuitry in detail.

Troubleshooting equipment includes the following:

Extender Card, Tektronix Part No. 067-3942-00.

20 MHz Oscilloscope, dual trace, delayed sweep (i.e. TELEQUIPMENT D67 or equivalent).

Voltmeter for power supplies (most multimeters are adequate).

The Calculator Interfacing Information Manual, Tektronix Part No. 070-1695-00, is optional. It provides design information regarding the 21 and 31 Calculator interface.

## SYSTEM WRITEUP ABSTRACTS

The Circuit Card Functions writeup describes how each circuit card is used in the plotter. It mentions the basic circuitry located on each card and some of the functions performed. The Circuit Card Functions writeup is designed to direct a technician to a detailed description of circuitry on each card. The detailed description of plotter circuitry is found in the Detailed Description subsection of this manual.

The System Description subsection gives a basic overview of plotter operation (see foldout Fig. 7-2 in the Charts and Schematics Section). It links together the functional information discussed separately in the other writeups in this manual. Knowledge of the System Description is necessary for a basic understanding of plotter electronics. The System Description also contains references to the information found in the Detailed Description subsection of this manual. Understanding the System Description and following through in the Detailed Description will help the technician troubleshoot the plotter's electronics.

The Detail Description subsection follows a format similar to that used in the System Description subsection. The following abstracts provide an overview of the contents in the Detailed Description subsection of this manual.

The Calculator Interface writeup details the electronics used to provide communication between the calculator and the 4661 Plotter. Included is handshake information for data transfer, data format information that includes timing and instruction decoding information. It also contains a comprehensive description of BCD-to-Binary data conversion within the plotter.

The Plotter Timing Circuits writeup details the electronics on the Timing card. The signals discussed in detail apply to all plotter activity except the Calculator Interface; however, the plotter timing signals are used in BCD-to-Binary conversion activity on the Data Converter card. Some of the memory addressing circuitry is also discussed in the Plotter Timing Circuits writeups.

The Plotter Data Processing and Velocity Generation writeup outlines the circuitry of the Data Processing and Velocity Generation diagram (Fig. 7-9 on a foldout in the Charts and Schematics Section). Detailed description of Data Processing and Velocity Generation circuitry follows in other writeups.

Registers and Storage Devices are described in three categories: Data Registers, Control Registers and Velocity Registers. Data registers include the data memories and Arithmetic Accumulator. Control registers include the Delta Sign Register, the Offscale Status Latch and the Halfway Counter. Velocity registers include the Quotient Register, Velocity Register, Multiply Register, Digital Integrator and Velocity Storage registers. Each functional writeup details the purpose and function of the registers involved.

The Arithmetic Circuits writeup is divided into three parts. First is a detailed description of the arithmetic unit. Second is a presentation of arithmetic operations performed within the plotter. Third is a description of offscale comparison circuitry. The arithmetic activity is described as to how the arithmetic is performed. Used in conjunction with the Plotter Control writeups, a thorough understanding of plotter data processing activity can be obtained.

The Velocity Circuits writeup describes the circuitry involved in velocity generation and velocity compensation. Mentioned superficially is Axis Control circuitry. The Velocity Generator card houses most of the velocity generation circuitry. The Velocity Compensator card houses most of the velocity compensation circuitry.

The Plotter Control Circuitry writeups provide detailed descriptions of data processing control routines. These routines are the Initial Program, which controls plotter activity during a power-up restart sequence; the Plotter Program, which controls data processing activity necessary to condition the registers for plotting a vector; and the RUN Sequence, which updates the Position Memory and Delta Memory when the pen is undertaking an axis move. For the description of data processing activity during a set zero command or instruction, refer to the Panel Interface writeup.

The Axis Control writeup describes the decoding of axis move commands and how they influence the RUN Sequence that updates the Position Memory and Delta Memory. Most of the circuitry residing on the Axis Control card is described in detail. The Axis Control is responsible for the execution of the RUN Sequence, routing the stepping pulses to the appropriate stepping motors and to help control axis data processing throughout the entire plotter circuitry.

The Panel Interface writeup describes the circuitry located on the Panel Interface card. The primary purpose of the Panel Interface is to decode the panel switches into plotter commands and to handle the plotter busy status to prevent the calculator and the plotter switch panel from controlling plotter activity simultaneously. The Panel Interface card also controls the data processing activity during a set zero command and houses the pen state register flip-flop, which determines the pen (up or down) position except in remote moves to the offscale plotting boundary. A remote move is a calculator initiated vector, which starts after a Remote 32 or Remote 36 command when Y axis data is received.

The Step Drive writeup describes the interfacing electronics that provide power to the stepping motors. Included in the Step Drive circuits are a digital-to-analog converter that provides drive voltage, two bridge amplifiers that determine the polarity to which the motor windings are energized, and a reversible sequence counter that determines the direction of motor rotation.

The Power Supply writeup describes the power supply circuitry used by the plotter.

### CIRCUIT CARD FUNCTIONS

Primary functions of the circuit cards in the plotter are given in this section. Detailed circuit operation is discussed by functional entity in the Detailed Description Subsection.

#### Axis Control Card

The Axis Control card provides central control of pen movement in the X and Y axes. Pen movement commands come to this card from the Panel Interface card for manual moves, the Program card for calculator initiated moves, and the Offscale card for initial moves caused by a power-up restart signal. The Axis Control card performs updating of the Position Memory and the Delta Memory by direct arithmetic unit control during any pen movement along the X or Y axis. In addition, the velocity stepping pulses from the velocity generating circuitry are routed to the appropriate stepping motor. The Axis Control card also signals the stepping motors which direction to move.

The Axis Control card circuitry generates the RUN Sequence discussed in conjunction with the Plotter Program. The Axis Control writeup details the majority of the circuitry found on the Axis Control card. Both writeups appear under the general heading of Plotter Control Circuitry.

## System Description—4661 Service

### Calculator Interface

The Calculator Interface is composed of three circuit cards, Calculator Interface #1, Calculator Interface #2, and the Data Converter card. The main function of the Calculator Interface is to translate information coming from the calculator to a form that can be used by the plotter. Calculator Interface #1 decodes the calculator remote instructions into plotter commands. It also controls the interface handshake lines and decodes the sign bit of incoming coordinate data. The Calculator Interface #2 uses calculator timing signals to generate interface T-times (T0, T1, T2, etc.) that determine which BCD (Binary Coded Decimal) digit is on the interface data lines during the transmission of a calculator data word. These interface T-times are not to be confused with the plotter times generated on the Timing card. Calculator Interface #2 also scales the incoming data with respect to data exponent value as the data is loaded into a BCD-to-Binary converter on the Data Converter card. The Data Converter card changes the BCD data to the binary form used by the plotter and stores this binary information in the New Data Memory, also located on the Data Converter card. Memory addressing functions are routed from the Plotter Program to the New Data Memory on the Data Converter card. Detailed information is found in the writeup titled Calculator Interface.

### Data Card

The Data card contains the basic arithmetic unit consisting of an adder and an accumulator. The Position Memory and Delta Memory are also on this card. The arithmetic unit is used by the Program card to calculate pen distance movement, and to find the ratio of slow axis to fast axis movement. The arithmetic unit is used by the Axis Control card to incrementally update the Position Memory and Delta Memory during pen movement. A 3-bit status shift register on the Data card is used to determine which axis has the larger distance to move (also the fast axis) and the direction of axis movement for the X and Y axes. The arithmetic unit is also used by the Panel Interface card during the set zero command to place the contents of the Position Memory into the Zero Memory.

The Data card houses the basic arithmetic unit. Detailed description of the Data card circuitry can be found in the arithmetic discussion associated with the Plotter Data Processing and Velocity Generation writeup. Arithmetic unit control circuitry is discussed in detail in the Plotter Control Circuitry writeup.

### I/O Board

The I/O Board is the board that directly connects to the calculator interface cables and termination pack. It provides all required signals for proper communication

between the X-Y Plotter and the calculator. It also allows other peripherals to communicate with the same calculator. The I/O Board is composed of the same bus structure used by the interface for the Tektronix 21 and 31 Calculators. It has two major bus connections: one connection goes to the calculator, the other connection is either terminated with a termination pack or provides an extension of the calculator interface bus to which other peripherals may be connected. The plotter, if used with the Tektronix 21 or 31 Calculator, must have the bus properly terminated with a calculator-compatible termination pack.

### Mother Board

The Mother Board is the circuit board to which most of the other circuit cards in the plotter are connected, the two exceptions being the Panel Switch Board and the I/O Board. The Mother Board provides all the wiring between the circuit cards for routing signals and providing power. Wiring in the plotter not contained on the Mother Board includes wiring to the stepping motors, panel switch lines from the Panel Switch Board, calculator interface lines from the I/O Board, and a few power devices in the power supply circuits.

Descriptions of the Mother Board signals is included in the Index of Signal Names. A wire list for the Mother Board is also included in the manual. Both are found in the Wiring Section.

### Offscale Card

The Offscale card houses the plotter boundary checking circuitry, the Zero Memory, and the Initial Program (or start-up) control logic. The boundary checking circuitry compares data values of pen position with the plotting boundary constants, i.e., the maximum and minimum plotting limits. Results of the boundary comparisons are stored in a circulating boundary status register having outputs indicating X position is big or small and Y position is big or small. The Zero Memory stores the zero reference position or plotting origin. Initial Program control logic is activated by RST, the power status restart signal. The Initial Program initializes the Zero Memory to indicate a plotting origin near the lower left corner of the plotting surface. It initiates pen movement to the lower right corner of the plotting boundary (sensed with microswitches) and updates the Position Memory with the data values referencing the present pen position (the initial pen position).

The Offscale card has the Initial Program which is discussed in detail in the Initial Program writeup. The plotting boundary checking, or Offscale Comparison circuitry, is discussed in the Offscale Comparison writeup.

The Plotter Control Circuitry writeups (Plotter Program and RUN Sequence) indicate when the Offscale Comparison circuitry is asserted.

**Panel Interface Card**

The Panel Interface card allows the operator to communicate with the plotter electronics by using the panel switches. The Panel Interface card also controls the busy signals used by the rest of the plotter system. It also has the pen state register, which is part of the pen up and pen down control circuitry. The Panel Interface card provides central control for the set zero command. During the set zero command, contents of the Zero Memory are replaced with contents of the Position Memory. Both memories are located elsewhere in the plotter circuits.

Panel interface circuitry is discussed in detail in the Panel Interface writeup.

**Power Regulator Board (or Power Supply)**

The Power Regulator Board provides the power supplies necessary for plotter operation. It also provides an initial power-up restart signal (RST) that initializes plotter activity immediately after the power supplies have reached operating voltage levels. Input voltages to the Power Regulator Board are unregulated voltage sources of +27 V dc, +8 V dc and -27 V dc. Output voltages provided are an unregulated 880 V dc for electrostatic hold-down voltage to the platen, an unregulated +27 V dc to power the stepping motor circuits, a regulated +12 V dc for plotter panel switches and for generation of the electrostatic hold-down voltage, a regulated +5 V dc for the logic circuitry and pen solenoid voltages activated by a pen down command.

Detailed power supply descriptions can be found in the Power Supply writeup.

**Program Card**

The Program card controls the necessary data processing functions that precede a calculator initiated move being performed. The Program card calculates the next pen position and initiates an offscale boundary check. It then calculates the X and Y distance to be moved and stores this in the Delta Memory. The direction of pen movement is also determined, along with which axis has the greater distance to move. The halfway counter on the Data card is loaded, and the ratio of slow axis to fast axis movement is loaded into the quotient register on the Velocity Generator card. All this precedes pen movement, which is started with a RUN command to the Axis Control card. The offscale pen register is sensed both before and after a remote vector move to lift the pen or allow the pen to lower.

The Plotter Program writeup discusses in detail the data processing control functions involving the Program card.

**Step Drive Cards**

There are two Step Drive cards in the plotter, one each for the X and Y axes. Each Step Drive card converts the logic signals in the plotter into voltages and pulses required to drive the stepping motors. A sequence counter on each Step Drive card determines the polarity of the currents used to drive the two sets of coils in the respective stepping motor. Voltage to drive the stepping motors is proportional to the stepping frequency to compensate for the inductive load provided by the stepping motor coils. The current activation sequence of Fig. 6-1 depicts a clockwise rotation of the stepping motor. For counterclockwise rotation, the state count reverses and counts down.

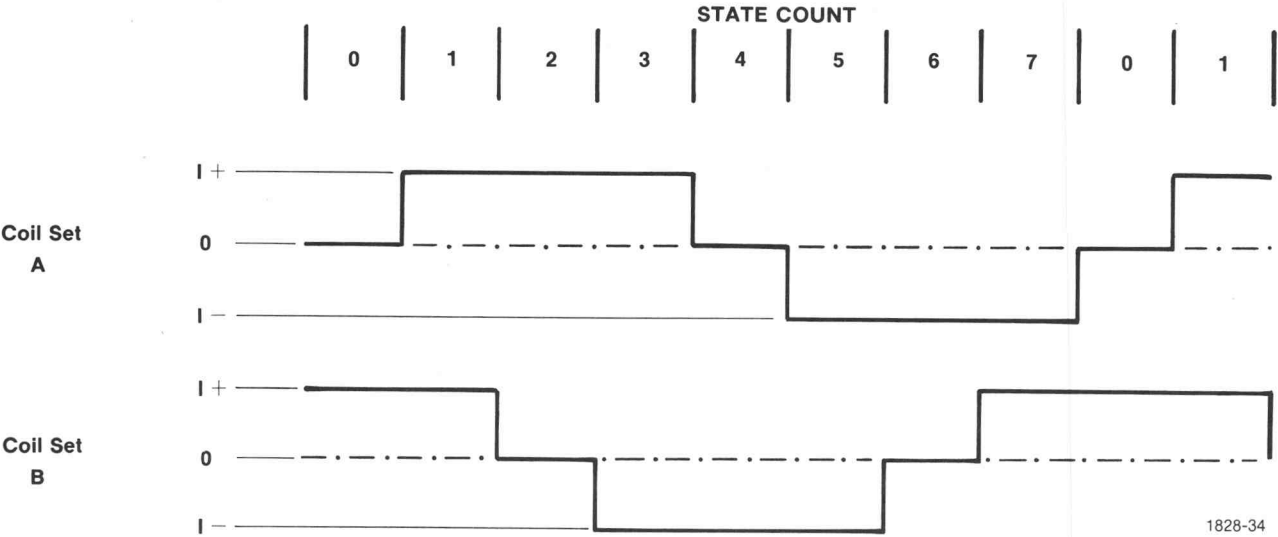


Fig. 6-1. Stepping motor coil actuation state diagram for clockwise motor rotation.

## System Description—4661 Service

The Step Drive circuits are described in detail in the Step Drive writeup. Voltage compensation is available via the Velocity Compensator card. The stepping pulses become available via the Axis Control card and are generated at the Velocity Generator card.

### Timing Card

The Timing card provides the basic timing signals used by the plotter (with exception of the Calculator Interface circuits which are controlled by external clock signals from the calculator). The basic timing signals for the plotter are shown in Fig. 6-2. The source of timing signal generation is a 2 MHz crystal oscillator from which the plotter timing signals are driven. Basic data operations within the plotter generally change at the end of CK for 1  $\mu$ s operations, or T9CK for the larger 10  $\mu$ s cycles. TA, TB, TC, and TD can be decoded, giving the sequential 1  $\mu$ s T-times during the 10  $\mu$ s cycle. These plotter T-times are T1 to T9 and are not to be confused with calculator interface timing.

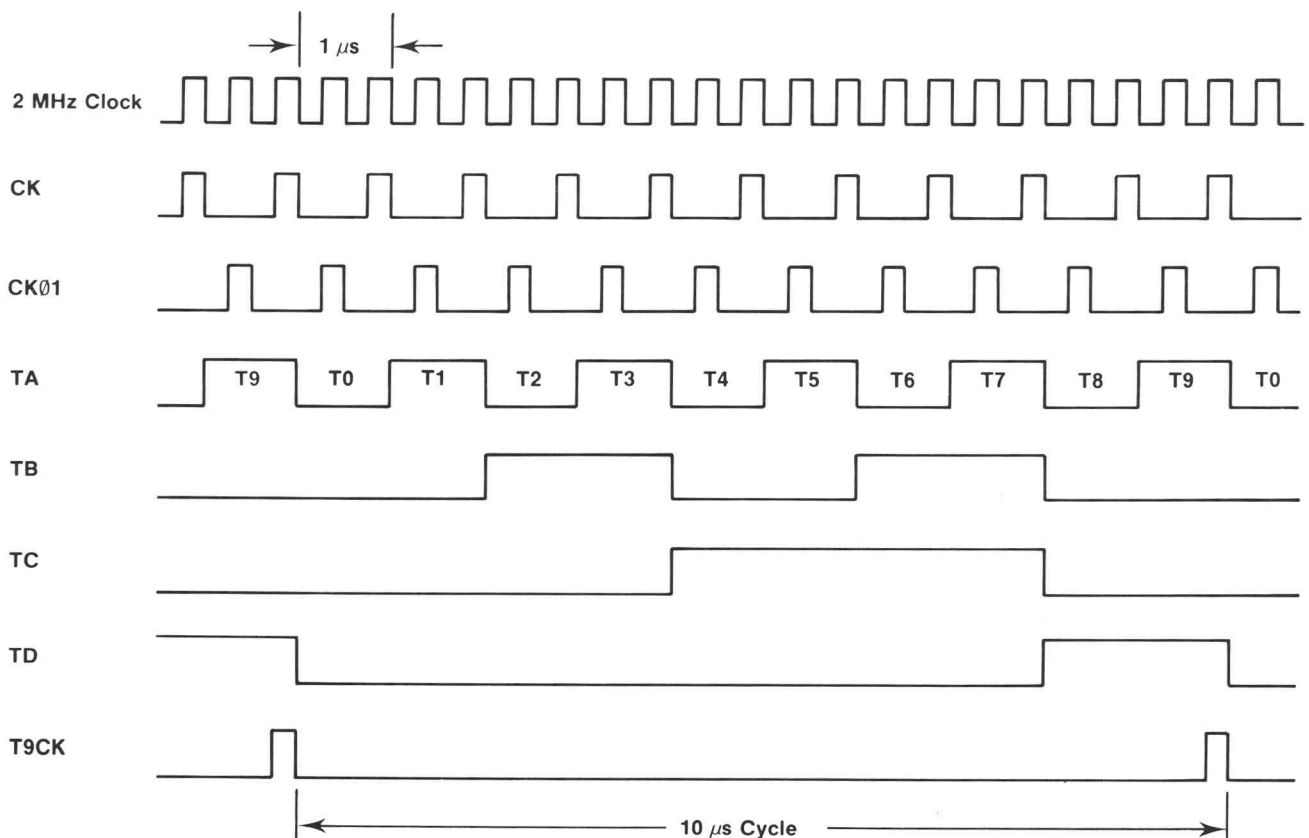
Generation of plotter timing signals is described in detail in the Plotter Timing Circuits writeup. The com-

binatorial logic for memory addressing, etc., is discussed fully in other descriptions where application of the signals is made.

### Velocity Compensator Card

The Velocity Compensator card provides the Step Drive cards with digital values representing axis pen velocity for each axis. It also channels the fast axis and slow axis stepping frequencies to the Axis Control card. A velocity register and quotient register are located on the Velocity Generator card. Their contents are respectively the fast axis velocity and ratio of slow axis movement to fast axis movement. Velocity storage registers, used by the Step Drive cards, are located on the Velocity Compensator card. The Velocity Compensator card stores the velocity used by the fast axis in the appropriate velocity storage register, determined by a signal line from the Axis Control card. The velocity of the slow axis is calculated by multiplying the contents of the velocity register and the quotient register. This product is then placed in the appropriate velocity storage register used by the slow axis.

See the Velocity Compensation writeup for details.



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Fig. 6-2. Plotter Timing Signals.

### Velocity Generator Card

The Velocity Generator card creates precisely metered pulse rates that determine the rate of pen movement. Two pulse rates are provided: one determines the velocity of the fast axis (the axis with the largest distance to move), the other determines the velocity of the slow axis. The Velocity Compensator card works in conjunction with the Velocity Generator card to provide the acceleration and

deceleration velocity profile used in a calculator initiated pen movement command. Manual movement velocities and a terminal velocity for large moves are determined by constants generated on the Velocity Generator card.

See the Velocity Generation writeup for details.

## SYSTEM DESCRIPTION

### INTRODUCTION

The Tektronix 4661 Digital X-Y Plotter is a digitally stepped plotter that interfaces with either the Tektronix 21 or 31 Calculator to provide graphic display of calculator computations. The plotting of information uses a vector format in which the pen moves in a straight line from one position to the next. Each position is defined by X axis and Y axis data expressed in inches. Pen movement is initiated upon the receipt of Y axis data. Commands are also available to lift and lower the pen and to establish a new origin or plotting reference. Data entry in each axis may be absolute data, which references the origin or zero position, or relative data, which references the last pen position. Commands may be entered in any sequence except that X data must be entered prior to Y data.

Paper of any type is held in place on the platen by electrostatic attraction. Writing is done with a nylon-tipped pen. Each axis of the plotter is driven by a 4-phase stepping motor that moves the pen bug on the axis shafts by means of plastic-covered cables. Each motor step results in .005 inch of linear motion in the addressed axis.

Refer to the basic block diagram Fig. 6-3. The Plotter Control circuitry supervises all plotting activity. It converts instructions generated by the calculator and the panel switches into command voltages used by the electromechanical hardware and its driving circuits. The Velocity Generation circuitry uses the commands issued by the Plotter Control circuitry, and sometimes the results of Plotter Control data processing, to generate the pulses used to drive the stepping motors. The electromechanical hardware includes two stepping motors, one each for the X and Y axes, and a solenoid for pen operation. The stepping motors and pen solenoid convert electrical signals into plotting activity by means of drive cables, pulleys, axis shafts, and cams. For mechanical information refer to the User's Manual and the Service Section of this manual.

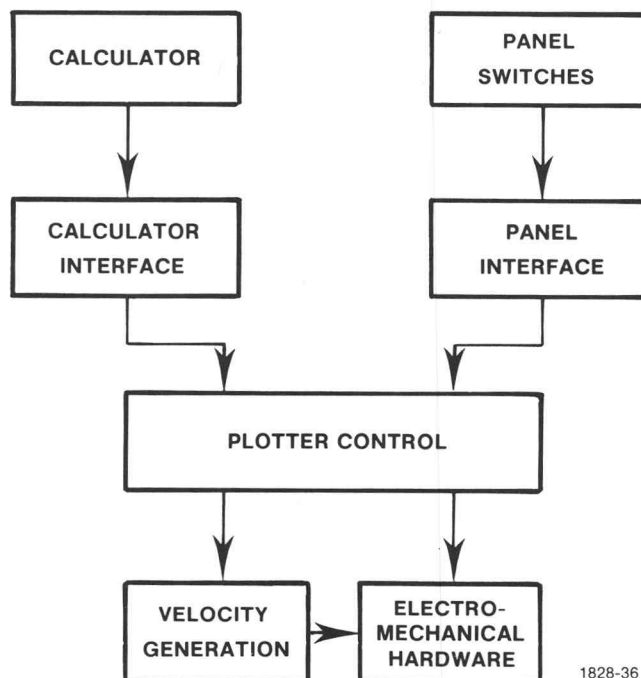
### SYSTEM DESCRIPTION

The central control functions that coordinate plotter activity are scattered throughout the system. Therefore, the circuits in this section are described as function entities rather than by circuit card. Refer to the system block diagram (Fig. 7-2 foldout) for the rest of the plotter system description.

#### Card Locations of Plotter Functions

Plotter circuitry functions are concentrated on the circuit cards in the following manner.

External control of the plotter may be asserted by the calculator through the Calculator Interface or by the panel switches through the Panel Interface.



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Fig. 6-3. Plotter Block Diagram.

## System Description—4661 Service

The Calculator Interface circuits involve three cards: Calculator Interface #1, Calculator Interface #2 and the Data Converter.

Panel Interface circuitry is concentrated on the Panel Interface card.

Speed of pen movement is governed by circuitry located predominantly on the Velocity Generator and Velocity Compensator cards. The Step Drive cards transform logic signals in the plotter to voltages and pulses required to drive the stepping motors.

The Initial Program, coordinating plotter activity when the power is first turned on, is located on the Offscale card. The Offscale card also handles the Offscale Boundary Checking circuitry.

The Plotter Program, which coordinates data processing activity prior to pen movement, is located on the Program card. A pen-down command is also enabled by circuitry on the Program card.

The arithmetic unit and some control registers are located on the Data card. The arithmetic unit performs most of the data processing activity.

Data Memories and Offscale Constants can be found on several circuit cards within the plotter. The New Data Memory is located on the Data Converter card; the Zero Memory and Offscale Constants are located on the Offscale card; the Position Memory and Delta Memory are located on the Data card. The RUN control sequence, which updates the Position Memory and Delta Memory during axis movement, is located on the Axis Control card. The Axis Control card also determines the axis stepping motor to be incremented.

The Set Zero control sequence resides on the Panel Interface card.

Plotter Timing, which governs all operations except for the Calculator Interface, is created by clock circuitry on the Timing card.

The gated control lines are encountered on most of the circuit cards within the plotter. Most of the gated control lines, however, are located on the Program card, the Timing card, the Offscale card, and the Axis Control card. The gated control lines use the command lines from the Interface circuitry and Plotter Control circuitry (Plotter Program, RUN, Set Zero, and Initial Program) to control the individual elements in the plotter system.

## Calculator Communication

The calculator communicates to the plotter circuitry through the Calculator Interface. Refer to the foldout system diagram Fig. 7-2. The Calculator Interface decodes a remote command issued by the calculator, and thus provides instructions and data that are used by the plotter to draw vectors. The remote commands utilized are shown in Table 6-1, assuming that the interface still recognizes a 3 in the ten's digit of the remote commands as the appropriate device address. Data entered via the calculator is plotted as inches of pen movement unless a HALF SCALE switch on the plotter panel is in. The data is then plotted to half the entered value.

Remote commands have no effect if the plotter is off line. The plotter is off line when it is executing a manual move or when the plotter is in the LOAD mode.

**TABLE 6-1**  
**REMOTE COMMANDS**

Remote 30	SET ZERO. Causes the Zero Memory or plotter origin to be updated with the present pen position value.
Remote 31	X ABSOLUTE. X position data is to be entered relative to the Zero Memory or plotter origin.
Remote 32	Y ABSOLUTE. Y position data is to be entered relative to the Zero Memory or plotter origin. A command to plot a vector, a move to the next coordinate position, is asserted.
Remote 33	PEN DOWN. Causes the pen to lower to the plotting surface.
Remote 34	PEN UP. Causes the pen to lift from the plotting surface.
Remote 35	X RELATIVE. X position data is to be entered relative to the present pen position.
Remote 36	Y RELATIVE. Y position data is to be entered relative to the present pen position. A command to plot a vector a move to the next coordinate position, is asserted.

The Calculator Interface circuits scale incoming data with respect to the data exponent and load up to four BCD (binary-coded decimal) digits into the BCD-to-Binary converter. The converter changes the BCD characters into 16-bit binary numbers arranged in four hexadecimal digits (four sets of four binary bits). Upon the completion of decoding Y data, the Plotter Program in the control circuitry is initiated, thus controlling the internal data processing. The Calculator Interface writeup provides a detailed discussion of the Calculator Interface and the BCD-to-Binary converter.

### Panel Communication

The panel switches enable the operator to manually control plotter circuitry. Refer to the foldout system diagram, Fig. 7-2. The switches communicate to the plotter circuitry through the Panel Interface. The Panel Interface buffers the switches to eliminate unwanted transients. It decodes the panel switch positions and issues instructions that manipulate plotter activity. It also provides for a visual indication of plotter status such as busy and power on. The switch functions are detailed both in Section 1 of this manual and in the Panel Interface writeup.

The panel switch positions issue commands allowing the operator to load paper into the plotter, to lift and lower the pen, to position the pen carriage on the plotting surface, to manually set zero or establish a plotting reference, and to enable plotting to half scale.

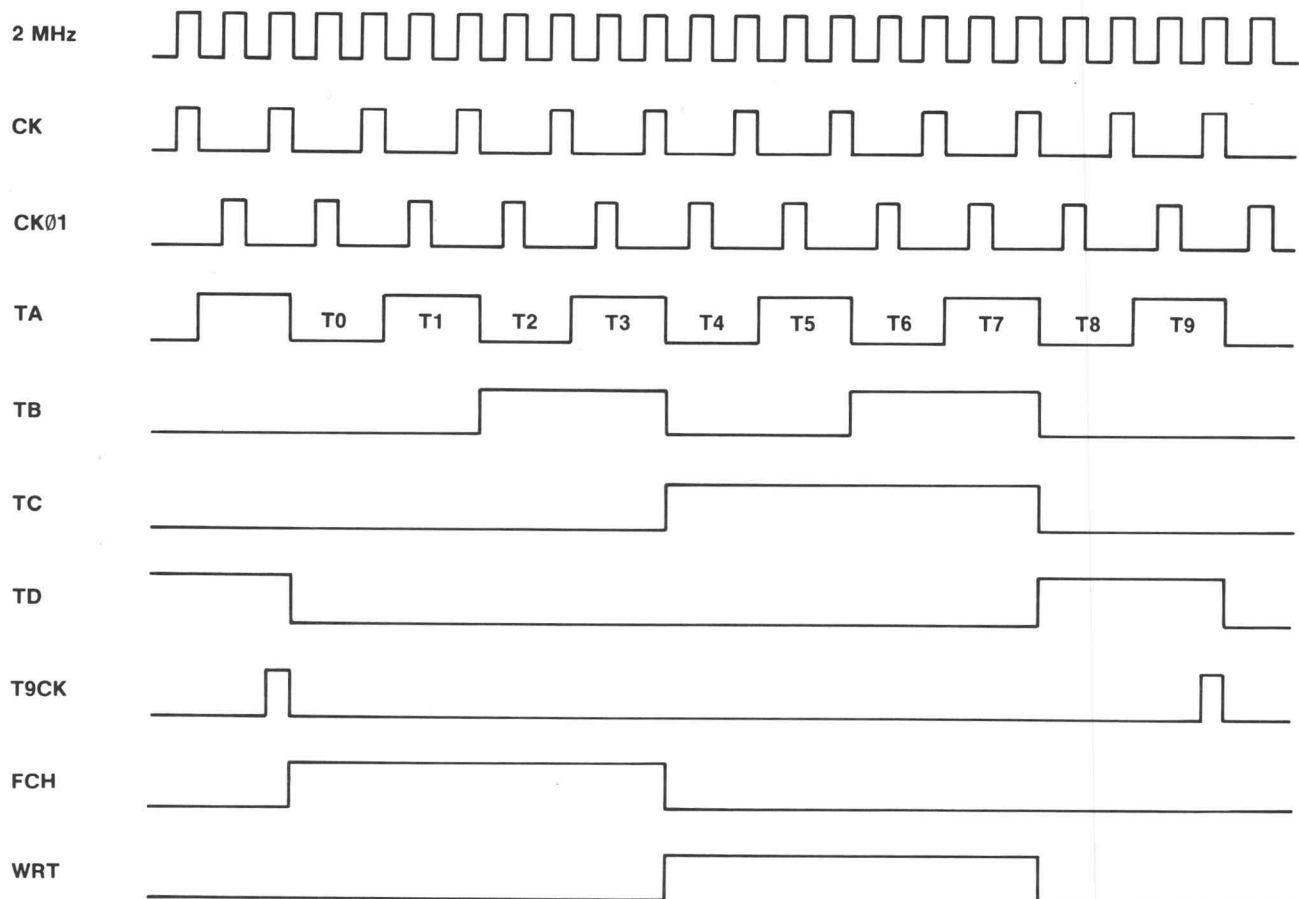
All panel switches, except for the LOAD switch, do not affect plotter behavior when the plotter is busy because of a remote command. The LOAD switch, when pressed, immediately lifts the pen and asserts control of the plotter after the last remote instruction is executed.

The plotter is off line when the LOAD switch is pressed, when the plotter is executing a manual move, and when the power is turned off. When off line, all remote instructions from the calculator are ignored.

For additional information refer to the writeup headed Panel Interface. The Panel Interface card includes the switch decoding circuits, a pen state register, the busy circuits and the set zero control circuits.

### Plotter Timing

The plotter timing signals are generated on the Timing card. These signals are used throughout the plotter circuitry except for Calculator Interface #1 and Calculator Interface #2. These interface cards use clock signals originating in the calculator, and are discussed in detail in the Calculator Interface writeup. The basic plotter timing signals, generated on the Timing card by a 2 MHz oscillator, counters, and gates, are illustrated in Fig. 6-4. The trailing edge of CK determines the transition between 1  $\mu$ s clock periods T0, T1, through T9. During each T-time, a small increment of data processing is performed. A 10  $\mu$ s cycle, determined by T9CK, is used by the wired programs



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Fig. 6-4. Basic Plotter Timing.

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in the Plotter Control circuitry. TA, TB, TC, and TD form a binary equivalent of each T-time. Data is fetched from the memories during FCH (T0, T1, T2, and T3). During WRT (T4, T5, T6, and T7) data may be written into a data memory. A detailed description is located in the Plotter Timing Circuits writeup.

### Plotter Control

Plotter Control provides sequential activation of plotter circuitry necessary to perform specific plotter instructions. Refer to the foldout system diagram Fig. 7-2. The Plotter Control consists of the Plotter Program, the RUN Sequence, the Set Zero Sequence and the Initial Program. Each is composed of a series of flip-flops, which issue commands to the gated control lines to activate specific portions of the plotter electronics. Each plotter control

sequence is described in detail in the Plotter Control Circuitry writeup.

The Initial Program is a set of flip-flops on the Offscale card. It is initiated by the RST restart signal that monitors the +5 V dc power supply. The Initial Program becomes active when power is first applied to the plotter or when power is interrupted. The Initial Program causes the Zero Memory to be loaded with an origin value indicating a position 0.16 inch inside the lower left corner of the plotting boundary (Fig. 6-5). The pen carriage is moved to the right boundary, closing the XLIM microswitch, then to the bottom, closing the YLIM microswitch. The Position Memory is loaded with values indicating the initial pen position (lower right corner). A detailed discussion can be found in the Initial Program writeup.

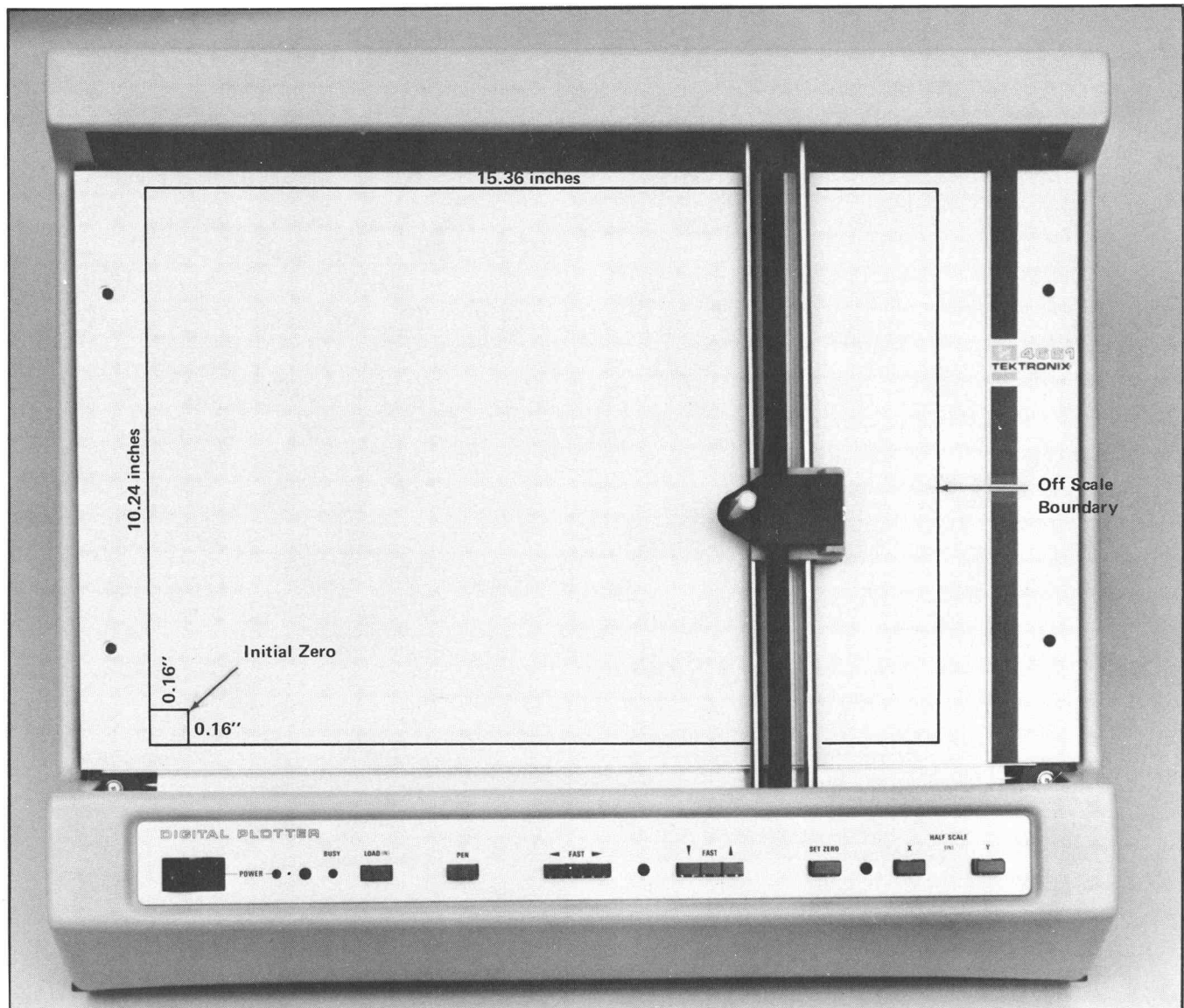


Fig. 6-5. Plotting Boundary & Initial Zero.

The Set Zero Sequence is a series of flip-flops on the Panel Interface card. The sequence is initiated by either a Remote 30 command from the calculator or by pressing the SET ZERO panel switch. The Set Zero Sequence provides the command lines necessary to replace information stored in the Zero Memory with the contents of the Position Memory. By doing this, the plotter origin ( $X=0$ ,  $Y=0$ ) becomes established at the present pen location. Additional details are presented in the writeup titled Panel Interface.

The RUN Sequence is a set of flip-flops located on the Axis Control card. Operation of the RUN Sequence is enabled by both the Plotter Program and by manual move instructions, including LOAD and Initial Program moves. Timing for the RUN Sequence comes from both the Plotter Timing and Axis Control circuitry. The RUN Sequence flip-flops issue the command lines necessary to update the Position Memory and Delta Memory during pen axis movement. Each time through, the RUN Sequence appropriate memory is updated by one increment. Additional information is presented in the section headed Plotter Program. See also the Axis Control description.

The Plotter Program is a series of flip-flops (on the Program card) that controls data processing activity for a calculator initiated move resulting from a remote Y data command (Remote 32 or 36). The Plotter Program Sequence is started immediately after conversion of Y data to binary form in the Calculator Interface circuitry. The Plotter Program sequence calculates the next pen position, initiates plotter boundary checks, calculates the distance to be moved and which axis has the greater distance to move, and calculates the ratio of axis movement for drawing vectors. Control registers are loaded by the Plotter Program with data status information used during axis movement. Control is then transferred to the RUN Sequence and Axis Control for pen movement. After pen movement, control then returns to the Plotter Program for limited post-move processing. Detailed operation is described following the Plotter Program heading. The Plotter Program foldout diagram is a chart illustrating the data processing sequence; it is read from left to right.

### Data Processing

Most of the data processing is handled by the arithmetic unit and the data memories. Plotter boundary checking is handled by the Offscale card. Checking circuitry on the Offscale card. Refer to Fig. 7-2, the System foldout diagram.

Each memory register is given a mnemonic, which is used in the text. See Table 6-2. Only the contents of the Zero Memory, the Position Memory, and the Delta Memory can be updated by the arithmetic unit. Use of these memories is discussed in detail in the descriptions on Plotter Control Circuitry and Plotter Arithmetic.

**TABLE 6-2**  
**DATA MEMORY REGISTERS**

NX, NY	Registers of New Data Memory. The New Data Memory, located on the Data Converter card, stores the X and Y coordinate positions entered via the calculator and converter to binary in the BCD-to-Binary converter.
ZX, ZY	Registers of the Zero Memory. The Zero Memory, located on the Offscale card, stores the position of the plotter origin (coordinate values $X=0$ , $Y=0$ ). The zero coordinate reference may reference any point on the plotter surface. The initial zero reference is 0.16 inch up from the front plotting boundary and 0.16 inch from the left plotting boundary.
PX, PY	Registers of the Position Memory. The Position Memory, located on the Data card, stores the value of the present pen location on the plotting surface.
DX, DY	Registers of the Delta Memory. The Delta Memory, located on the Data card, stores the distance to be moved in both the X and Y axes. This memory is also used in most of the data processing functions of the Plotter Program.
Offscale Constants	The Offscale Constants are generated on the Offscale card. These offscale values replace the pen position values when the calculator initiates a plotter move instruction that would place the pen outside the plotting boundary.

The arithmetic unit consists of an adder and accumulator that performs two's complement arithmetic on 16-bit binary numbers. The adder is a 4-bit full adder that operates on each of the four hexadecimal digits forming a 16-bit binary number. The operations are controlled by numerous lines from the gated control lines. Operations performed are addition, subtraction, incrementing, decrementing, multiplication by two, and division. Each of the operations is discussed in detail in the Plotter Data Processing writeup.

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### Offscale Checking

Plotter boundary checking is performed by circuitry on the Offscale card. The results are sent to control lines via four boundary flags indicating whether the pen position just calculated is on or exceeds the plotting boundary. The four flags indicate X big, X small, Y big, and Y small, which are the boundary conditions on the four sides of the plotting area. Detail description is found in the writeup titled Offscale Comparison. The circuitry is discussed in conjunction with plotter arithmetic activity.

### Velocity Generation

Refer to the foldout System Diagram Fig. 7-2. Velocity generation circuitry includes the Velocity Generator, the Velocity Compensator and the Axis Control. These three circuits prepare the stepping pulses and other signals necessary to operate the axis stepping motors through the Step Drive circuits.

The Velocity Generator uses a digital integrator and a quotient register to produce the fast and slow stepping frequencies necessary to draw vectors. The digital integrator produces pulses that determine the velocity of the fast axis. The quotient register is used to reduce this frequency to generate the pulses used by the slow axis. Velocity acceleration and deceleration circuitry is also included to allow the motors to operate at velocities up to 15.625 inches per second without losing position reference. During manual moves, the Velocity Generator

issues stepping pulses that allow the stepping motors to operate at velocities of 0.061 ips for slow manual moves and at 3.91 ips for fast manual moves.

The Velocity Compensator produces binary numbers proportional to the speed of stepping motor operation. These numbers are used by the Step Drive circuits to produce the operating voltages for the stepping motors. The stepping motors are an inductive load, which requires additional drive as the velocity or stepping frequency is increased. The programming of motor drive voltage with respect to velocity enables the motors to track properly and not loose position.

Detail description of the Velocity Generator and Velocity Compensator circuits can be found in the Velocity Circuits writeup in the Detail Description subsection of this manual.

The Axis Control circuitry switches the stepping pulses from the Velocity Generator to the appropriate axis stepping motors. It also causes a portion of the RUN Sequence to activate. The RUN Sequence updates the Position Memory and Delta Memory for either the X or Y axis as commanded by control logic in the Axis Control circuitry. Detail discussion of Axis Control circuitry is titled Axis Control. The RUN Sequence is described in both the Plotter Program writeup and the Axis Control writeup in the Detailed Description subsection of this manual.

## DETAILED DESCRIPTION

### CALCULATOR INTERFACE

The Calculator Interface obtains information from the calculator and makes it compatible for use in the plotter data circuits. The information transferred is instructions and data. The Calculator Interface circuits for the plotter are located on the Calculator Interface #1, Calculator Interface #2, and Data Converter cards. The foldout Calculator Interface Diagram, Fig. 7-3, is a block diagram of Calculator Interface operation. A schematic reference key is included with the foldout. Calculator Interface timing is illustrated by Fig. 7-4 and Fig. 7-5 on the Interface Timing foldout diagram.

A comprehensive discussion of the Tektronix 21 and 31 Calculator Interface signals can be found in the manual titled 21 and 31 Calculator Interfacing Information, Tektronix Part No. 070-1695-00.

### Handshake Routine

The handshake routine used by the plotter consists of electronic signals that provide communication control for

the interface and exchange of information. Handshake signals from the plotter give the calculator the following information:

I have been addressed ( $\overline{AC}$  is low).

I am busy, please wait ( $\overline{FXTTP}$  is high).

I am ready to receive data in scientific notation ( $\overline{FXTTP}$  is low).

Handshake signals from the calculator give the plotter the following information:

I have a device address and instruction on the remote bus ( $\overline{AVS}$  goes low).

I am sending a data word on the data bus ( $\overline{DW}$  is low).

Other signals controlling the interface are two free-running clock signals from the calculator ( $\overline{ECP1}$  and

ECP2) that provide interface timing and a strobe signal (ESYNC) that indicates the beginning of a data word. The clock signals enable the proper retrieval of information from the data bus. They are also used in the data scaling circuitry of the interface circuits (Calculator Interface #1, Calculator Interface #2, and Data Converter cards).

Refer to the foldouts titled Calculator Interface Diagram (Fig. 7-3) and Interface Timing Diagram (Fig. 7-5). To start plotter activity, the calculator places a device address and an instruction on two, 4-bit remote instruction lines labeled Tens Digit and Units Digit (TD1 to TD8 and UD1 to UD8); each is a BCD (Binary Coded Decimal) digit from 0 to 9. An address valid strobe,  $\overline{AVS}$ , is then sent to the plotter enabling it to recognize a device command and instruction. If the proper device number for the plotter (factory set as 3 in the Tens Digit of a remote instruction) has been received by the plotter, the plotter pulls the  $\overline{AC}$  line low to acknowledge being addressed. The plotter then decodes an instruction on the Units Digit line, which determines plotter activity. The  $\overline{FXTTP}$  line is not pulled low when the plotter is busy ( $\overline{PLBY}$  is low) except when an X data instruction requires that a X data be sent on the data lines (DIO1, DIO2, DIO4, and DIO8).  $\overline{FXTTP}$  goes low when the plotter is ready to accept data from the data lines. Upon receipt of  $\overline{FXTTP}$  by the calculator, the calculator initiates  $\overline{ESYNC}$  and  $\overline{DW}$  and places data, in scientific notation, on the data lines. While the calculator transmits 16-bits of data during calculator T-times T0 through T15,  $\overline{DW}$  is low.  $\overline{FXTTP}$  is released during T9. After the data is scaled and loaded into the BCD-to-Binary converter on the Data Converter card,  $\overline{AC}$  is released.

### Interface Data Format

Interface timing is provided by two free-running clocks ( $\overline{ECP1}$  and  $\overline{ECP2}$ ) from the calculator. The calculator T-times used in this interface are defined by the trailing edge of  $\overline{ECP2}$  via a T-time generator (U5 on the Calculator Interface card). The trailing edge of  $\overline{ECP1}$  is used to latch data and sign information via the data sign decoder, the exponent scaler, and the BCD-to-Binary converter circuits in the Calculator Interface.

The calculator strobes data on the data lines (DIO1, DIO2, DIO4, and DIO8) during the 16 calculator T-times that make up a data word. These T-times are illustrated by Table 6-3, Fig. 6-6, and the Interface Timing foldout, Fig. 7-5. These T-times refer only to the calculator interface and are not to be confused with other plotter timing signals generated on the Timing card. If the plotter is in full-scale mode, the data illustrated in Table 6-3 and Fig. 6-6, relates directly to inches of pen movement of position.

The data format is illustrated by Table 6-3. This tables gives the calculator T-times of data transferred and gives the significance of each digit in the calculator data word.

**TABLE 6-3  
CALCULATOR T-TIMES**

T0	Status bits or flag bits. DIO1 Negative Exponent. DIO2 Scientific Notation. DIO4 Negative Mantissa. DIO8 Decimal Point Displayed.
T1	Decimal point position on the calculator display.
T2	LSD (least significant digit) of the exponent in BCD.
T3	MSD (most significant digit) of the exponent in BCD.
T4	LSD of the mantissa in BCD (not displayed).
T5	Second LSD of the mantissa in BCD (not displayed).
T6	Third LSD of the mantissa in BCD (first LSD displayed).
T15	MSD of the mantissa in BCD.

$\pm$	M	M	M	M	M	M	M	M	M	M	$\pm$	E	E	Display
T0	T15	T14	T13	T12	T11	T10	T9	T8	T7	T6	T0	T3	T2	T-time
<p>M = mantissa E = exponent</p>														

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Fig. 6-6. Calculator Display of Scientific Notation.

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As the data enters the Calculator Interface circuitry, which occurs with every plotter instruction, the sign of the mantissa is decoded and placed in an instruction latch indicating the sign of Y data, unless an X data instruction is received. Since only a Y data command initiates vector drawing, the data converted by pen commands (Remote 33 and 34) and the set zero command (Remote 30) do not affect plotter performance. On Calculator Interface #1, the instruction latches are loaded with sign information from the data sign decoder. The exponent is decoded and determines the number of times the INCK signal clocks BCD data into registers of the BCD-to-Binary converter, thus scaling the data. If the exponent is less than -2, a value of 00.00 is loaded into the BCD-to-Binary converter. If the exponent is greater than one, a value of 99.99 is loaded into the BCD-to-Binary converter. The binary output is loaded into the NY register (new Y data) of the New Data Memory unless an X data plotter instruction is being executed.

### Decoded Instructions

Instructions to the plotter from the instruction latch are described in Table 6-4. Most of these signals appear on the Calculator Interface #1 schematic. Refer also to the Calculator Interface block diagram, Fig. 7-3.

**TABLE 6-4  
INSTRUCTION LINES FROM  
THE CALCULATOR INTERFACE**

JPEN	A pen activation command which works in conjunction with PROGUP.
PROGUP	When high and JPEN is asserted, a pen down command is issued. When low and JPEN is asserted, a pen up command is issued.
PRZO	A set zero instruction is asserted.
XA	When high, X data is absolute; when low, X data is relative.
XM	Indicates that X data is minus.
YA	When high, Y data is absolute; when low, Y data is relative.
YM	Indicates that Y data is minus.
XCONV	When high, X data is converted to binary. When low, Y data is converted to binary.
YMFF	Asserts plot commands (PLCO and JPROG) after Y data is converted to binary.

Whenever the calculator sends a valid remote command to the plotter, the processing shown in Table 6-5 occurs. Most signals referenced can be located on the Calculator Interface #1 schematic.

**TABLE 6-5  
INSTRUCTION DECODING**

Remote 30	Set Zero. PRZO goes high during $\overline{DW}$ . XCONV goes low. Contents of the Zero Memory are replaced with contents of the Position Memory. Data on the data lines is converted and placed in the NY register of the New Data Memory.
Remote 31	X Absolute. XA goes high. XCONV goes high. Data on the data lines is converted and placed in the NX register of the New Data Memory.
Remote 32	Y Absolute. YA goes high. XCONV goes low. YMFF goes high. Data on the data lines is converted and placed in the NY register of the New Data Memory. A plot command is issued causing the new data to be plotted.
Remote 33	Pen Down. JPEN goes high during $\overline{DW}$ . PROGUP remains high. XCONV goes low. The pen, if enabled by other circuitry, is allowed to lower to the plotting surface. Data on the data lines is converted and placed in the NY register of the New Data Memory.
Remote 34	Pen Up. JPEN goes high during DW. PROGUP goes low while the address is valid. XCONV goes low. The pen is either lifted from the plotting surface or remains up. Data on the data lines is converted and placed in the NY register of the New Data Memory.
Remote 35	X Relative. XA goes low. XCONV goes high. Data on the data lines is converted and placed in the NX register of the New Data Memory.
Remote 36	Y Relative. YA goes low. XCONV goes low. YMFF goes high. Data on the data lines is converted and placed in the NY register of the New Data Memory. A plot command is issued causing the new data to be plotted.
Remote 37	Not assigned.
Remote 38	Not assigned.
Remote 39	Not assigned.

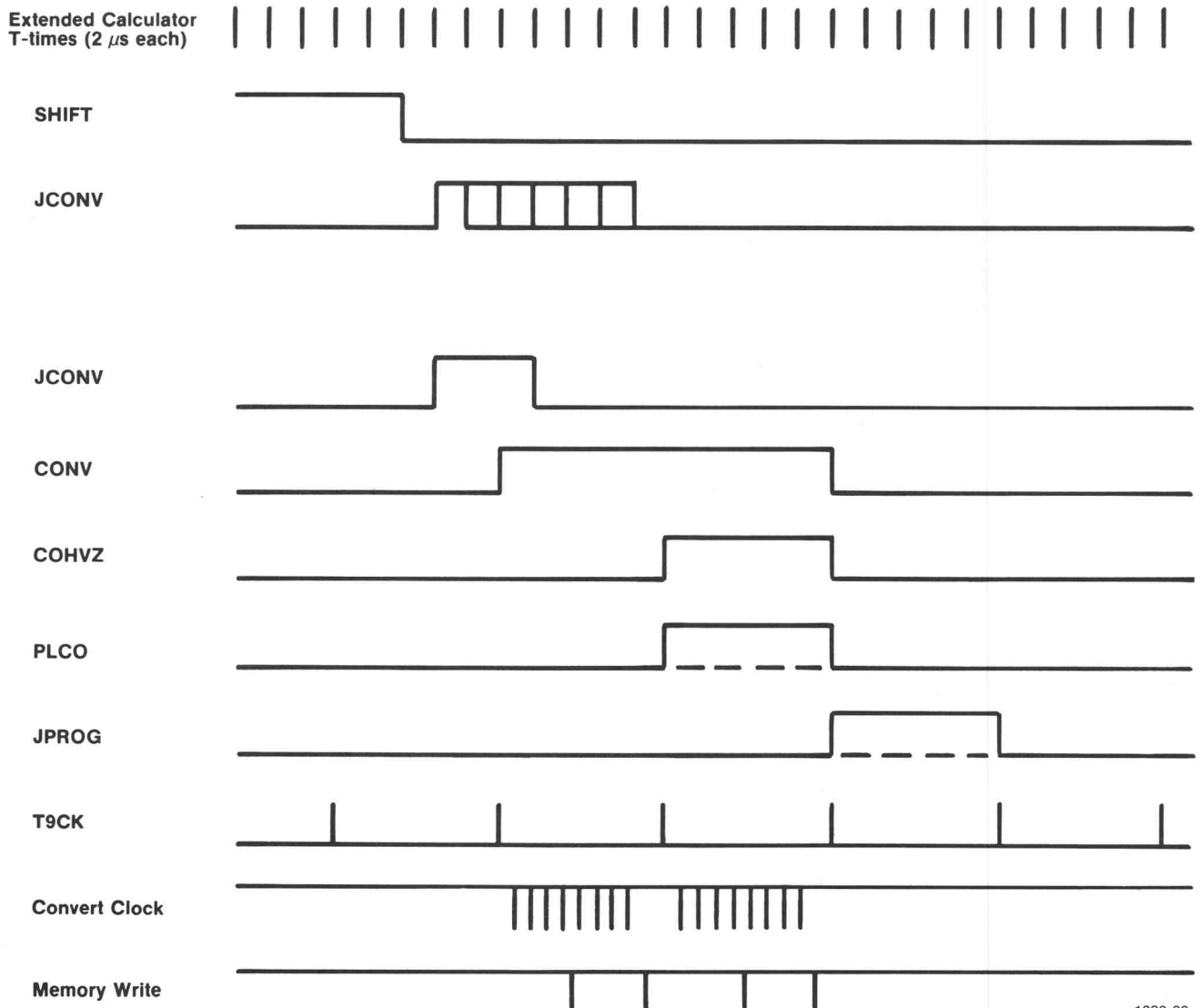
The plotter is factory wired to accept remote commands with a tens digit equal to three. Other tens digits may be selected via a jumper on the Calculator Interface #1 card.

### BCD-to-Binary Conversion

Data conversion from BCD (Binary Coded Decimal) to binary is accomplished on the Data Converter card. Refer to the Data Converter schematic. A converter timing diagram (Fig. 6-7) is also helpful. BCD-to-Binary conversion uses a subtract-three algorithm illustrated by Fig. 6-8. To perform this conversion, a shift register partitioned into 4-bit segments is loaded with BCD data. The contents are shifted right with the rightmost digit being the serial binary output. After each right shift, the bits in each 4-bit segment are compared with 8. If the binary value is 0 to 7, there is no change in value. If the binary value is 8 to 15, it is

subtracted by three. The next right shift yields the next binary digit. The process repeats until the BCD-to-Binary conversion is completed.

Referring to the Data Converter schematic, BCD data enters the conversion register through CAL 1, CAL 2, CAL 4, and CAL 8. The data is already preshifted by one, such that the rightmost digit is the first binary digit. Four conversion clock cycles take place, causing the first four binary digits to wrap around to the left end of the conversion register. These four bits are then loaded in parallel into the New Data Memory (U12). Four more conversion clock cycles take place and the second four binary digits are loaded into the New Data Memory. At this time CONV2 goes high and the conversion process continues for two more sets of 4-bit words. The total binary data value is 16-bits long and is in absolute value



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Fig. 6-7. Converter Timing.

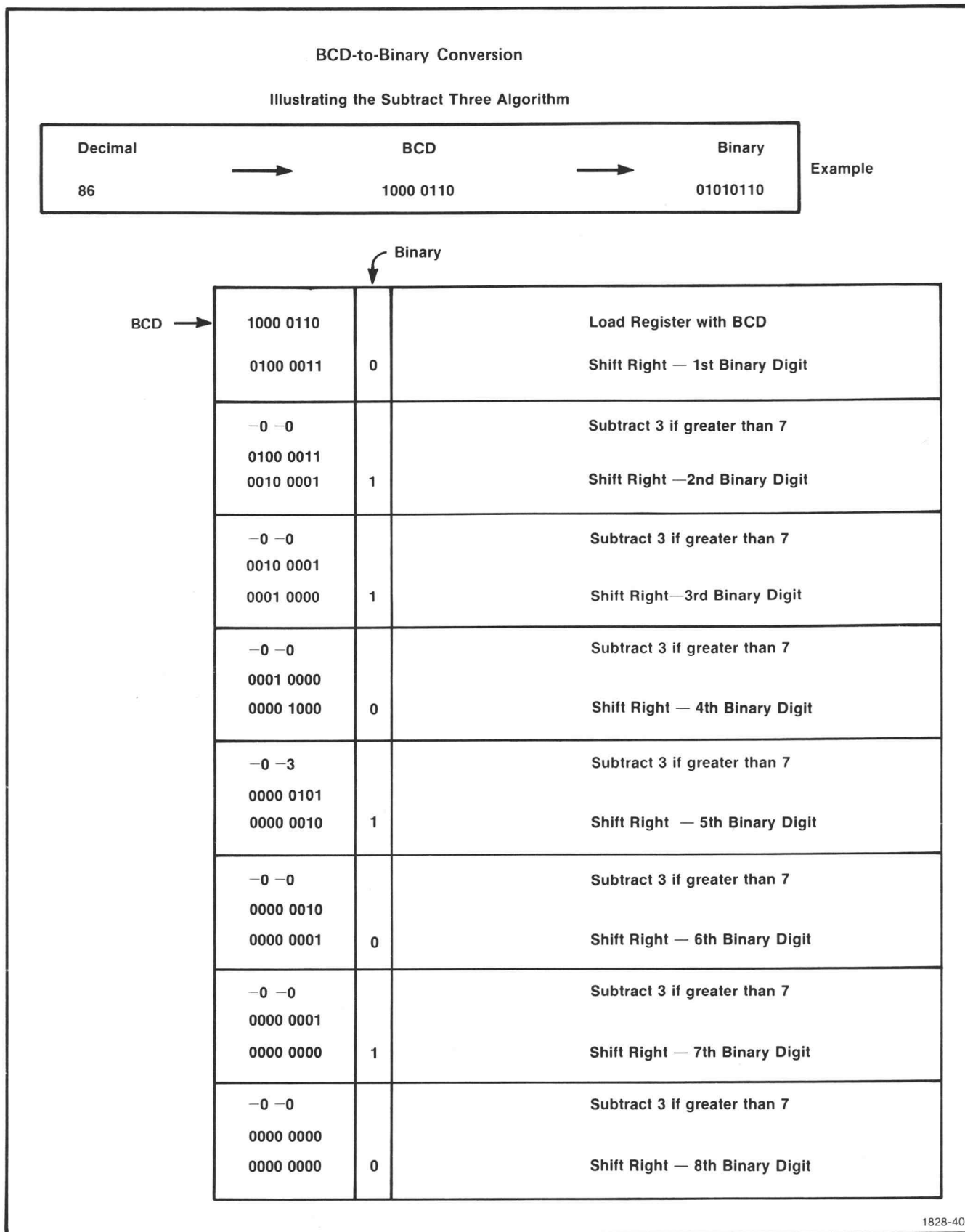


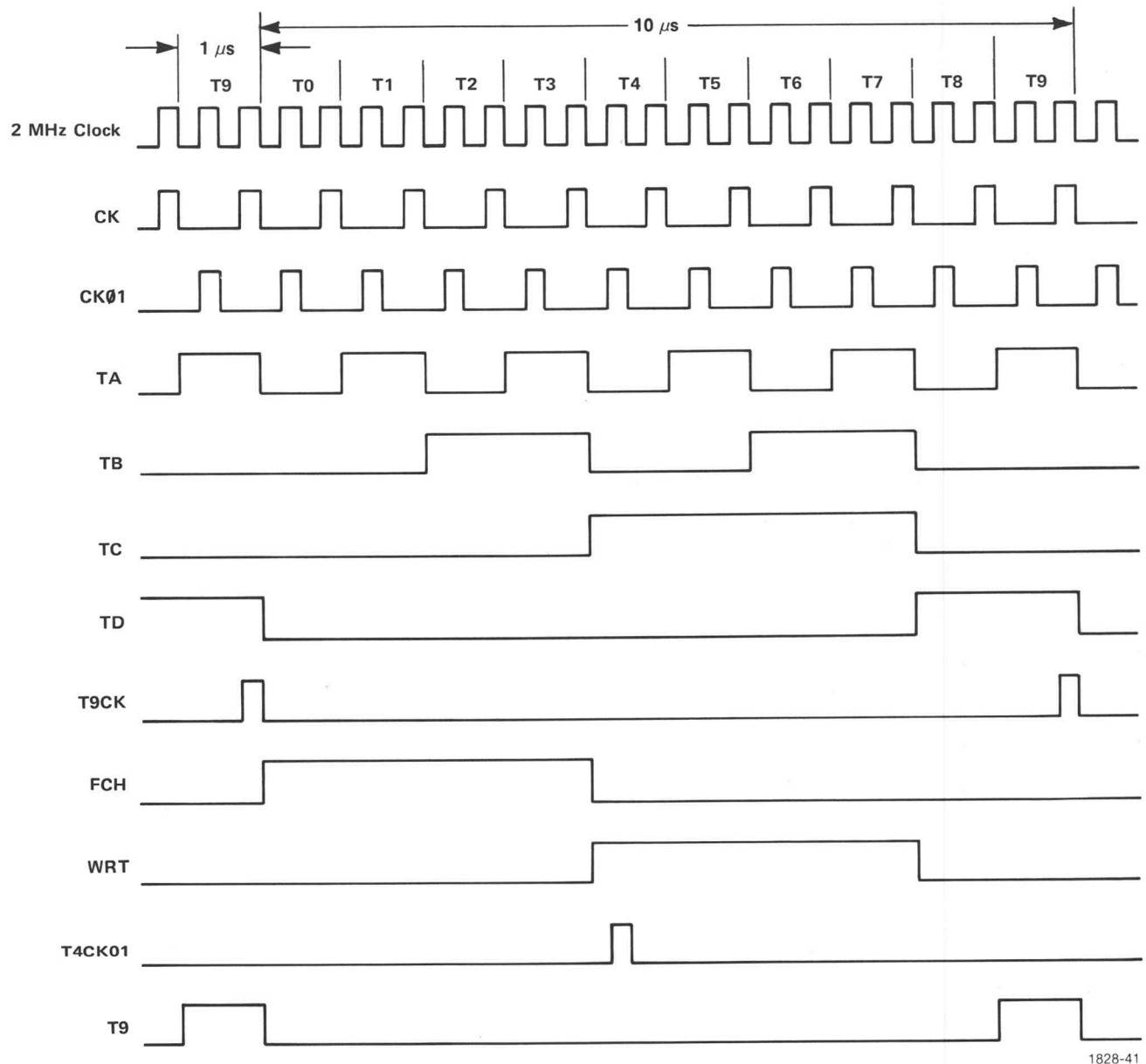
Fig. 6-8. BCD-to-Binary conversion by the subtract three algorithm.

binary format. Sign information is stored as XM and YM on Calculator Interface #1, and is used to perform the 2's complement (to make negative) when the central plotter control circuits retrieve the data.

Logic (other than the conversion register and the New Data Memory) on the Data Converter card is responsible for converter timing, memory addressing, and memory timing. XCONV, when high, addresses the NX register (X data) of the New Data Memory during the data conversion process. P00 is from the plotter program circuitry. When low, it addresses X data during information retrieval. P07 clears the plot command flip-flop U1B.

## PLOTTER TIMING CIRCUITS

For the following discussion, refer to the schematic of the Timing card and the plotter timing diagram of Fig. 6-9. The Timing card generates the clock signals used by all the plotter circuitry except for the Calculator Interface. (Refer to the Calculator Interface writeup for interface timing information.) The Timing card is also largely responsible for handling the memory addressing functions within the plotter. Definitions of the signal line mnemonics can be found in the Index of Signal Names in Section 5 of this manual.



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Fig. 6-9. Plotter Timing Diagram.

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### Crystal Oscillator

The crystal oscillator is an astable multivibrator consisting of U9, Y1, C5, R2, and R3. The frequency of 2 MHz is determined by the series resonant frequency of the crystal Y1. A filter and pulse shaper following the crystal oscillator create a precise square-wave output for the plotter timing circuits.

### Clock Gating

Refer to the timing diagram Fig. 6-9 and the Timing card schematic. The basic 2 MHz clock is counted down by U3B to provide two clock phases for generating CK and CK01. The trailing edge of the CK clock pulse occurs at the transition of the plotter T-times. CK01 is used predominantly to strobe or latch data within a plotter T-time.  $\overline{CK}$  and  $\overline{CK01}$  are the logical inverse of CK and CK01.

Decade counter U7 provides a 10  $\mu$ s cycle of timing signals, TA, TB, TC, and TD. These are decoded to give ten plotter T-times, T0 through T9. Each major data processing function is handled by the 10  $\mu$ s interval defined at the trailing edge of T9CK. T9CK is the CK clock pulse that occurs during the T9 time. T4CK01 is the CK01 clock pulse that occurs during T4 time. T4CK01 is employed predominantly by the Velocity Compensation circuitry.

FCH, the memory fetch time, takes place during T0, T1, T2 and T3. WRT, the memory write time, takes place during T4, T5, T6, and T7. During FCH, a data value or offscale constant is loaded into the arithmetic accumulator. During WRT, the Zero Memory, the Position Memory, or the Delta Memory may be updated. Arithmetic operations are also performed by the arithmetic unit during FCH.

### Memory Addressing

Much of the plotter timing circuitry on the Timing card performs memory addressing for the Position Memory and Delta Memory. MAY, which address Y data if high, is also used to address data in the Zero Memory. Data is fetched from a memory during FCH. Signals TA and TB strobe the memory contents onto the new data lines. If accumulator contents are to be written into a memory, a memory write occurs during WRT. The CK01 clock is used to write the data into memory registers. Memory addressing signal lines are as follows:

$\overline{MEMSEL}$	When low, the Position Memory and Delta Memory on the Data Board are selected.
$\overline{MWRT}$	When low, writing into the Position Memory and Delta Memory is enabled.

MAP	When high, the Position Memory is addressed. When low, the Delta Memory is addressed. $\overline{MEMSEL}$ must be low.
MAY	When high, Y data is addressed. When low, X data is addressed.
$\overline{FCH+WRT}$	Asserts $\overline{ACCK}$ and $\overline{ACLD}$ on the Offscale card to cause data to enter and leave the arithmetic accumulator during memory fetch and memory write operations.

Input lines are from the various plotter control circuits involved with data processing functions.

### Arithmetic Carry

The Timing card, along with its timing functions and memory addressing functions, also handles the carry generated in the arithmetic unit on the Data card. The Data Processing foldout diagram (Fig. 7-9) shows the layout of data processing and velocity generation circuitry. Refer also to the Timing card schematic.

The carry from the arithmetic unit enters the Timing card via AUCRYOUT. Flip-flop U3A inhibits arithmetic carry propagation during T0, and at the same time allows SUB or GATE+1 to provide an initial carry to the arithmetic unit via AUCRYIN. Arithmetic activity is discussed in detail in the Arithmetic Operations writeup.

## PLOTTER DATA PROCESSING AND VELOCITY GENERATION

Refer to the foldout diagram on plotter data processing and velocity generation (Fig. 7-9). This diagram illustrates the relationships between the memories and various control devices within the plotter. The circuits illustrated provide the arithmetic functions, plotting boundary comparisons, the velocity generation functions, and velocity compensation functions necessary for plotter operation. Plotter timing, plotter interfacing, and plotter control circuitry are discussed separately.

Registers and storage devices can be divided into three functional groups: data registers, control registers, and velocity registers. Data registers are used for most of the data processing arithmetic and use 16-bit binary data words partitioned into 4-bit bytes. The data registers include the NX and NY registers of the New Data Memory, the ZX and ZY registers of the Zero Memory, the PX and PY

registers of the Position Memory, the DX and DY registers of the Delta Memory, and the Arithmetic Accumulator. These registers communicate with each other through the Arithmetic Adder over the following data lines:

New Data  $\overline{ND1}$ ,  $\overline{ND2}$ ,  $\overline{ND4}$ ,  $\overline{ND8}$

Accumulator AC1, AC2, AC4, AC8

Sum Lines SUM1, SUM2, SUM4, SUM8

The Initial and Offscale Position constants are hard-wired constants used as data for plotter data processing arithmetic.

Control registers are used as flags that are interrogated by the plotter control circuitry to determine the course of plotter activity. Control registers include the Delta Sign Register, the Offscale Status Latch, and the Halfway Counter. The Delta Sign Register stores indicators for the direction of pen movement and the axis with the farthest distance to move. The Offscale Status Latch stores the plotter boundary conditions. The Halfway Counter output determines whether the pen is to accelerate or decelerate.

Velocity registers include the Velocity Register, the Quotient Register, the Velocity Storage registers, and the Multiply Register. The Velocity Register and the Quotient Register are 16-bit registers that are used to generate the stepping frequencies for the fast and slow axis circuits, which drive the stepping motors. The Multiply Register and Velocity Storage registers are 6-bit registers that determine and store binary values used to generate the operating voltages used by the stepping motors. A Digital Integrator is used to generate the stepping frequency for the fast axis. Its output frequency is dependent upon the velocity value used as an input, either from the Velocity Register or from a selected velocity constant. The Quotient Register is used by the Variable Frequency Divider to generate the slow axis stepping frequency and by the Multiplier to calculate a voltage compensation value for the slow axis stepping motor. Arithmetic involving directly the velocity registers uses serial arithmetic to minimize the number of electronic components required.

Active components illustrated on the plotter data processing and velocity generation diagram provide the arithmetic functions and velocity generation functions within the plotter.

Basic data processing arithmetic is governed by the plotter control circuitry. The arithmetic is performed using data registers, the Arithmetic Adder, and the Arithmetic Accumulator.

Offscale comparison is done using data that enters and leaves the Arithmetic Accumulator. The selected data is compared in the Offscale Comparison Adder with hard-wired Offscale Comparison constants. The result of the comparison updates the contents of the Offscale Status Latch.

Velocity generation is performed using the Digital Integrator to produce an output stepping frequency proportional to the velocity selected by a data selector. The Acceleration/Deceleration Control circuitry uses the Velocity Register, the RMPDN signal from the Halfway Counter, and the RMPGATE signal from the integrator (stepping frequency) to generate the acceleration and deceleration velocity profile.

Velocity compensation circuitry loads the Velocity Storage registers with data used to produce the operating voltage for the stepping motors. Data entering the Velocity Storage registers are constants for manual moves. The six most significant bits of fast axis pen velocity or the six most significant bits of slow axis pen velocity are calculated as a product of the Quotient Register contents and fast axis velocity value.

Detail description of circuitry shown on the plotter data processing and velocity generation foldout diagram (Fig. 7-9) is found in the following writeups. Refer to the appropriate schematics if necessary. Fig. 7-9 is to be used to locate the appropriate schematic for components mentioned in the following writeups.

## DATA REGISTERS

### Arithmetic Accumulator

Contents of the Arithmetic Accumulator (U7, U8, U9 and U10) are used to update the Position Memory (U14), Delta Memory (U14), and the Zero Memory (U19). Accumulator contents are also used to load the Halfway Counter (U3, U4 and U5) with a value such that an overflow occurs when half the number of steps required for a vector move clock the register. FSTSTP in conjunction with  $\overline{CK}$ , clocks the Halfway Counter once for each axis step. During the program DIVIDE operation, 16 sequential accumulator sign bits (ACS) generate the ratio of small axis to large axis movement stored in the Quotient Register (U9, U14). Sign information, indicating direction of pen movement and the axis with the greater distance to move, is stored in the Delta Sign Register (U11A, U12A and U12B).

## System Description—4661 Service

### New Data Memory

The NX and NY registers of the New Data Memory (U12) are found on the Data Converter card and provide data to the plotter circuits from the BCD-to-Binary converter associated with the Calculator Interface. The memory contains absolute value binary information representing data entered via the calculator. Sign values for this information are from signal lines (XM and YM) on the Calculator Interface #1 card.

### Zero Memory

The Offscale card houses the hard-wired initial and offscale position constants as well as the Zero Memory (ZX and ZY in U19). The Zero Memory stores the origin reference position to which absolute moves are referenced. The hard-wired constants assert their values on the new data lines. ( $\overline{ND1}$ ,  $\overline{ND2}$ ,  $\overline{ND4}$ ,  $\overline{DN8}$ ). The initial constants are asserted on the new data lines during the Initial Program to initialize the Zero Memory and Position Memory. The offscale constants are asserted on the new data lines during specific portions of the Plotter Program if an offscale condition exists (the pen is to remain on the offscale plotting boundary or is to move to the offscale plotting boundary).

### Position Memory and Delta Memory

The Data card houses the Position Memory (PX and PY in U14) and the Delta Memory (DX and DY also in U14). The Position Memory stores the present pen position value (located on the plotting surface). The Delta Memory stores the distance to be moved in both the X and Y axes. The Delta Memory is also used as a temporary storage register during the Plotter Program data processing activity.

## CONTROL REGISTERS

### Delta Sign Register

The Delta Sign Register is a 3-bit shift register (U11A, U12A, and U12B) on the Data card. It is updated during the Plotter Program and stores information to indicate the direction of pen movement in the X and Y axes. It also indicates which axis has the greater distance to move. Outputs of the Delta Sign Register are as follows:

XDP	X Delta is Positive (move right)
YDM	Y Delta is Minus (move forward)
YDB	Y Delta is Big (Y is larger than X)
XDB	X Delta is Big (X is larger than Y)

### Halfway Counter

The Halfway Counter (U3, U4 and U5) is located on the Data card. During a Plotter Program cycle (P12), the Halfway Counter is loaded with a value such that an overflow signal occurs when incremented by half the stepping pulses required to draw a vector to completion. When the output of the Halfway Counter goes high, the deceleration phase of the velocity profile is to occur. Both velocity generation and the Plotter Program are discussed later in this section.

### Offscale Status Latch

The Offscale Status Latch is a circulating register with an output register located on the Offscale Board (see Fig. 6-10). Each calculation of the next pen position updates the circulating register, the output of which is then stored in an output register. Additional information is included in the Plotter Control Circuitry writeups and Offscale Checking writeup. Each STP2ND period of the RUN Sequence also updates the Offscale Status Latch. Data in the Offscale Status Latch indicates the offscale plotting boundary status of the pen position. These offscale conditions represent X big, X small, Y big, and Y small (the outer four sides of the plotting area).

### Offscale Pen Register

The Offscale Pen Register is on the Program Board (see Fig. 6-11). It uses outputs from the Offscale Status Latch on the Offscale card to store the offscale condition for two consecutive pen locations in U12. During P13 of the Plotter Program, the Offscale Pen Register is updated with the offscale condition of the previous pen position. The Offscale Pen Register is interrogated to determine whether or not the pen is to be allowed to lower to the plotting surface. The pen lifts before a calculator initiated move to the offscale plotting boundary. The pen is allowed to lower after a move to within the plotting boundary. If pen movement is to take place, a 35 ms delay is triggered, allowing the pen movement to complete.

## VELOCITY REGISTERS

### Quotient Register

The Quotient Register (U9 and U14) is located on the Velocity Generator card. During the 16 cycles of the division process, controlled by the Plotter Program control circuitry, the Quotient Register is loaded with the ratio of slow axis movement to fast axis movement via ACS, the sign bit from the Arithmetic Accumulator on the Data card. The Quotient Register supplies quotient information to the Variable Frequency Divider (U10 and U15, sometimes called a synchronous rate multiplier) for creating the SLWSTP stepping pulses used by the slow axis stepping motor. The Quotient Register (U9 and U14) with the Velocity Register (U1 and U6) is also used by the Multiplier on the Velocity Compensator card to provide a Velocity Storage register with a number portional to the slow axis velocity.

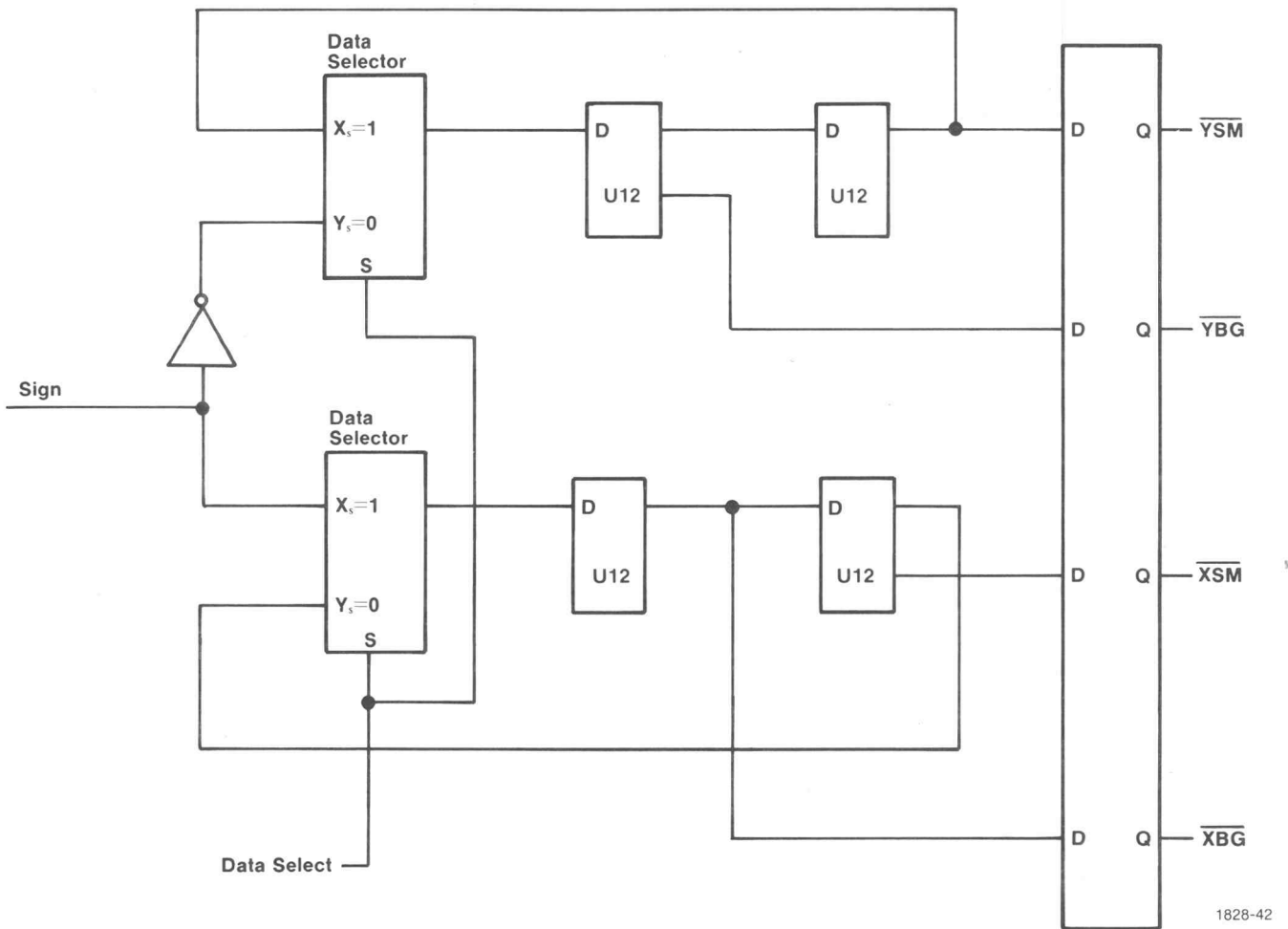


Fig. 6-10. Offscale Status Latch. It is located on the Offscale card.

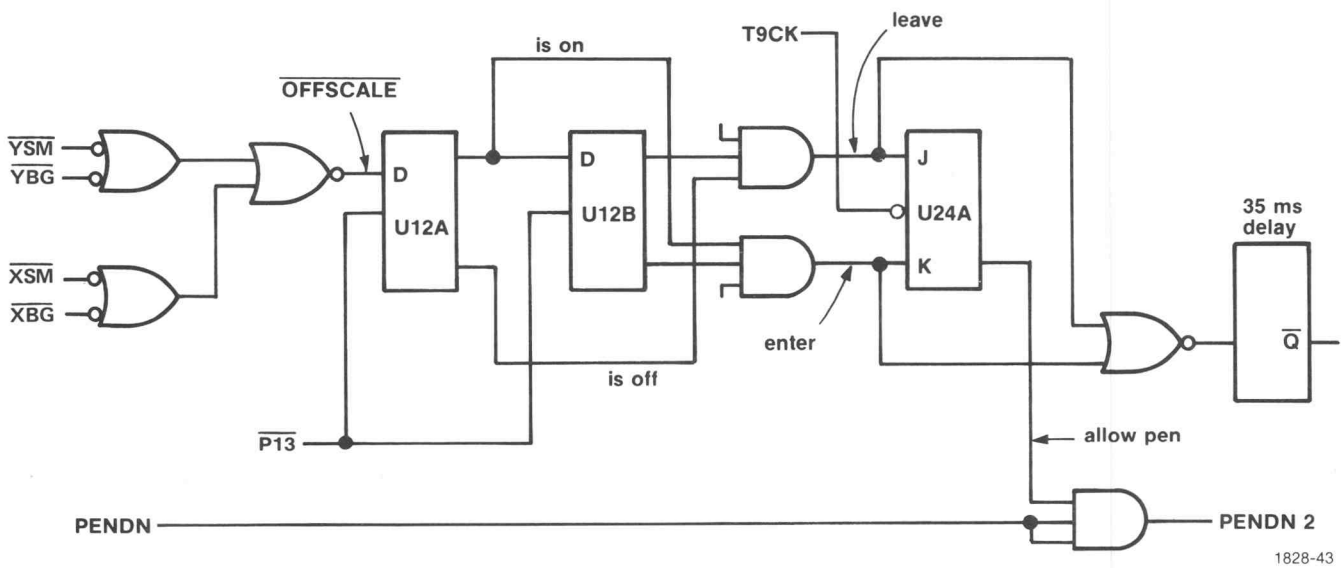


Fig. 6-11. Offscale Pin Register. It is located on the Program card.

### Multiply Register

The Multiply Register (U13) on the Velocity Compensator card acts as an accumulator for the multiply operation. During each 10  $\mu$ s of pen movement, the six most significant bits of pen velocity for both the X and Y axes are calculated. The results of the calculations are stored in the respective Velocity Storage registers (U16 and U20). During the 1  $\mu$ s plotter times T0, T1, and T2, the Multiply Register (U13) is loaded with the six most significant bits of the Velocity Register (U1 and U6 via V1). During T3, the fast axis Velocity Storage register is updated. During T4, T5, and T6, a six-bit product of the Velocity Register (via V32) and the Quotient Register (U9 via VQ1 through VQ32) representing the velocity of the slow axis, is placed in the Multiply Register (U13). During T7, the slow-axis Velocity Storage register is updated. During manual moves, appropriate binary constants are loaded into the Velocity Storage registers.

### Velocity Register

The Velocity Register (U1 and U6) is a shift register on the Velocity Generator card that maintains the velocity value used by the Digital Integrator (U2 and U4) during the generation of the acceleration/deceleration velocity profile. It is preloaded with an initial velocity (from U20) during JRUN preceding the RUN Sequence. The Velocity Register (U1 and U6) is updated by the Acceleration/Deceleration Control circuitry (via U2B) in the generation of the velocity profile. The Velocity Register also provides a terminal velocity indicator (TV), which selects the terminal velocity constant (via U20 and U18A) used by the Digital Integrator for rapid pin movement. Upon reaching terminal velocity, the Velocity Register is continuously incremented or decremented (via U2B) to maintain a pen position reference. The velocity contents ( $\overline{V1}$ ,  $\overline{V32}$ ) and the terminal velocity indicator (TV) are also available to the multiplier on the Velocity Compensator card to load velocity information into the Velocity Storage registers used for voltage compensation by the stepping motors.

### Velocity Storage Registers

Both the X Velocity Storage Register (U20) and the Y Velocity Storage Register (U16) are located on the Velocity Compensator card. The values placed in them from the Multiply Register (U13) correspond to the velocities of the respective stepping motors. Outputs of the Velocity Storage registers provide operating voltage compensation for the stepping motors through the Step Drive cards. Stepping motors require operating voltages that are proportional to their velocities or stepping frequencies.

## ARITHMETIC CIRCUITS

Refer to the foldout on plotter data processing (Fig. 7-9) to find the appropriate schematic having the reference parts and to follow circuit behavior between circuit cards.

Most of the data processing activity is performed by the basic arithmetic unit under control of plotter control circuitry. The majority of the basic arithmetic unit circuitry is located on the Data card with timing and memory addressing functions channeled through the Timing card. The basic arithmetic unit performs two's complement arithmetic and consists of the data memories, an Arithmetic Adder, an accumulator, and the appropriate gating functions.

Offscale comparison is done simultaneously with calculations for pen position. An Offscale Comparison Adder is responsible for this calculation, which updates the Offscale Status Latch. Offscale comparison circuitry is located on the Offscale card.

### Basic Arithmetic Unit

The basic arithmetic unit performs two's complement arithmetic and consists of the Arithmetic Adder (U2) and the Arithmetic Accumulator (U7, U8, U9, and U10) on the Data card. Carry information is routed through flip-flop U3 on the Timing card. Gated data lines into the Arithmetic Adder include the carry (AUCRYIN), the new data lines ( $\overline{ND1}$ ,  $\overline{ND2}$ ,  $\overline{ND4}$ , and  $\overline{ND8}$ ) and the accumulator data lines (AC1, AC2, AC4, and AC8). The Arithmetic Accumulator is controlled by the  $\overline{ACCK}$  clock signal and the ACLD accumulator load signal; both are from the Offscale card.

### Data Format For Basic Arithmetic

Fig. 6-12 illustrates the data used by the basic arithmetic unit and the data memories. The data memories include the New Data Memory (NX and NY), the Zero Memory (ZX and ZY), the Position Memory (PX and PY), and the Delta Memory (DX and DY). The binary data word is 16-bit, two's complement binary. S is the sign bit of the number and X is a binary digit of the data. Data is transferred as four hexadecimal characters over the new data lines, the accumulator data lines, and the adder output lines (SUM1, SUM2, SUM4, and SUM8).

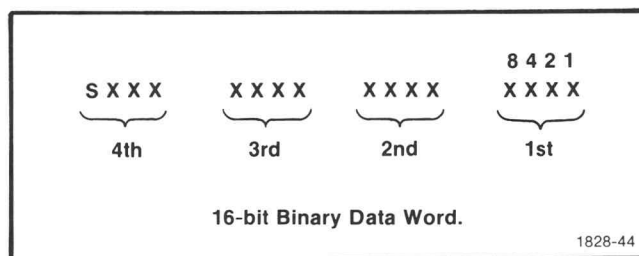


Fig. 6-12. Arithmetic Data Format.

## ARITHMETIC OPERATIONS

The arithmetic operations of incrementing, decrementing, addition, loading the accumulator, subtraction, multiplication by two and division are described in the following text. Refer to the Data Processing foldout diagram (Fig. 7-9) as necessary. Refer to the Plotter Control writeups for information describing when specific arithmetic functions are asserted. These writeups include Initial Program, Plotter Program, Axis Control and Panel Interface.

### Incrementing

To perform a data incrementing function, an initial carry bit (binary one) is added to data on the new data lines ( $\overline{ND1}$ ,  $\overline{ND2}$ ,  $\overline{ND4}$ ,  $\overline{ND8}$ ) when  $\overline{GATE+1}$  is low. The initial carry bit is added whenever the value on the new data lines is to be incremented or two's complement subtraction is to be performed. The data incrementing function is asserted by the stepping signals from the RUN Sequence on the Axis Control card.

### Decrementing

Subtracting one from the data (the decrementing function) is performed by placing logical highs (the two's complement equivalent of  $-1$ ) on the accumulator data lines ( $\overline{AC1}$ ,  $\overline{AC2}$ ,  $\overline{AC4}$ ,  $\overline{AC8}$ ) when  $\overline{GATE-1}$  is low;  $-1$  is therefore added to data arriving on the new data lines. The decrementing function is asserted by the RUN Sequence on the Axis Control card.

### Addition

Addition is performed when  $\overline{GATEAC}$  is high.  $\overline{GATEAC}$ , when high, allows the Arithmetic Accumulator contents to be added to data arriving on the new data lines (except when  $\overline{GATE-1}$  is low). The sum from adding the accumulator contents to the new data is stored in the Arithmetic Accumulator.

### Loading the Accumulator

When  $\overline{GATEAC}$  is low, zero is added to the data arriving on the new data lines, thus loading the new data into the Arithmetic Accumulator. If  $\overline{SUB}$  is asserted when  $\overline{GATEAC}$  is low, the two's complement of new data is loaded into the Arithmetic Accumulator. See Fig. 6-13.

### Subtraction

Subtraction is performed by adding the two's complement of data on the new data lines to data on the accumulator lines. The data complementing function is asserted when  $\overline{SUB}$  goes low. See Fig. 6-13.  $\overline{SUB}$ , when low, also asserts  $\overline{GATE+1}$  (on the Timing card) to complete the two's complement by adding an initial carry

bit to the complemented data. The difference (accumulator minus new data) is shifted into the Arithmetic Accumulator.

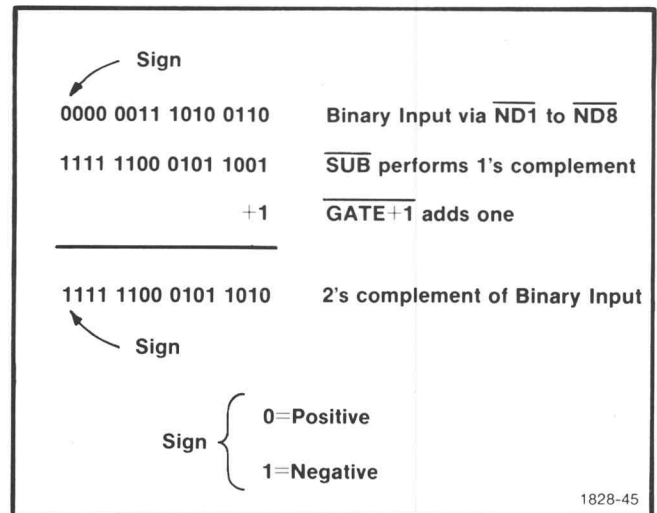


Fig. 6-13. Obtaining the 2's complement for subtraction.

### Multiplication By Two

Multiplication by two is accomplished when the contents of the Arithmetic Accumulator ( $\overline{U7}$ ,  $\overline{U8}$ ,  $\overline{U9}$ , and  $\overline{U10}$  on the Data card) are shifted to the left one position. This occurs when  $\overline{ACLD}$  is low and  $\overline{ACC\overline{K}}$  clock is received, asserted by an extra shift command.  $\overline{EXTSHFT}$ , the extra shift command, is generated on the Program card during plotter time  $\overline{T9}$ . It is then routed to the Offscale card to enable  $\overline{ACC\overline{K}}$  to clock the Arithmetic Accumulator when  $\overline{ACLD}$  is low.  $\overline{ACLD}$  is normally high, except during plotter times  $\overline{T8}$  and  $\overline{T9}$ , to allow the other data processing functions to be performed.

### Division

Division is controlled by the Plotter Program flip-flops on the Program card. The Quotient Register ( $\overline{U9}$  and  $\overline{U14}$ ) is initially loaded with a high in the least significant bit ( $\overline{QT15}$ ) during  $\overline{P12}$  of the Plotter Program with all the other positions of the Quotient Register remaining low. The initial high at  $\overline{QT15}$  is used to terminate the division and is then discarded. The Arithmetic Accumulator is initially loaded with the smaller delta or distance to be moved before starting the division algorithm. Data stored in the  $\overline{DX}$  and  $\overline{DY}$  registers is used for the calculation. Following is the division algorithm:

1. If the last quotient bit ( $\overline{QT15}$ ) is high, subtract the larger delta from the accumulator contents. If the last quotient bit is low, add the larger delta to the accumulator contents.

## System Description—4661 Service

2. Shift the complement of the accumulator sign bit into quotient register at location QT15.

3. Multiply the accumulator by two and repeat steps 1-3 until 16 iterations are completed.

For additional information, refer to the Plotter Program writeup describing plotter data processing control functions.

### OFFSCALE COMPARISON

Refer to the foldout diagram (Fig. 7-9) on plotter data processing. Use it to locate the appropriate schematic if necessary. Offscale comparison adder (U7) takes position data (from SUM1, SUM2, SUM4, and SUM8) as it is being entered into the Arithmetic Accumulator and compares it with zero, the small offscale plotting limit. X small ( $\overline{XSM}$ ) indicates the left offscale plotting boundary condition and Y small ( $\overline{YSM}$ ) indicates the front offscale plotting boundary condition. As position data is being written into the appropriate memory from the Arithmetic Accumulator, output from the accumulator (AC1, AC2, AC4 and AC8) is compared with the maximum plotting limit for the appropriate axis. X big ( $\overline{XBG}$ ) indicates the right offscale plotting boundary condition and Y big ( $\overline{YBG}$ ) indicates the rear offscale plotting boundary condition. The signs of the offscale comparison are captured by the Offscale Status Latch (U12 and U13) and made available to the plotter circuitry through U14C, U14E, U17B and U17C on the Offscale card.

Offscale comparison takes place during P01 and P05 of the Plotter Program and during STP2ND of the RUN Sequence. Generation of these signals is described in the Plotter Control writeups titled Plotter Program and Axis Control. Refer to the Offscale card schematic. P01 and P05 are regenerated by U14A when it receives a FCHNEW signal from the Program card. STP2ND is generated by the Axis Control card during a RUN Sequence. Data selector U11 determines from which side of the Arithmetic Accumulator data is taken for offscale comparison. U7 performs the comparison. Comparison sign information, which indicates the offscale boundary conditions, is captured by the Offscale Status Latch (U12) during T3 and T7 of the appropriate plotter cycles. If the pin-1 input of U13 is high, the X inputs (pins 3, 6, 10, and 13) are selected. If the pin-1 input of U13 is low, the Y inputs (pins 2, 5, 11, and 14) are selected. Pin-1 of U13 determines when the X axis offscale conditions or the Y axis offscale conditions are updated.

## VELOCITY CIRCUITS

Refer to the Data Processing and Velocity Generation foldout diagram Fig. 7-9. Most of the velocity generation circuitry is located on the Velocity Generator card with signal frequency reduction being performed on the Velocity Compensator card. Velocity generation circuitry creates the stepping frequencies that are used to produce FSTSTP and SLWSTP, the fast and slow axis stepping frequencies respectively. Acceleration/Deceleration Control circuitry provides the velocity profile used to accelerate and decelerate the pen velocity as the result of a remote command to move.

Velocity compensation circuitry provides 6-bit velocity values to the stepping motor circuits (via the Storage Registers) to control the stepping motor operating voltages. The multiplier places values, proportional to the pen velocities in each axis, sequentially into the Multiply Register. Velocity Storage registers are updated every 10  $\mu$ s during pen movement by values placed in the Multiply Register.

Serial arithmetic is used throughout the velocity circuitry to minimize the required number of components. Serial defines the sequential bit order in which the data is operated on. In addition for instance, the LSB's (least significant bits) for both numbers are added; the sum is stored in an accumulator (holding register) and the carry (if any) is propagated for addition with the next higher bit order. As only one "full adder" is used in the serial process, the data must be circulated to gain exposure to the adder. Circulation of the data registers occur by "right shifting" the register on each clock pulse. Register lengths used in the Velocity Generator are 16-bit long. If the LSB output is connected to the MSB (most significant bit) input of a shift register, and the LSB is the first out, data within the register will have recirculated after 16 clock pulses. In the process of recirculation each bit position ( $2^0, 2^1, \dots, 2^{15}$ ) will have been exposed to the adder in order of ascending binary weight.

### VELOCITY GENERATION

Use the foldout diagram Fig. 7-9 to find the appropriate schematic for component location if necessary. Most of the circuitry is on the Velocity Generator card. Velocity generation circuitry consists of a Digital Integrator (U2A and U4), a Velocity Register (U1 and U6), Velocity Constants (outputs of U20), a data selector (U18), a Quotient Register (U9 and U14), a Variable Frequency Divider (U10 and U15) and Acceleration/Deceleration Control circuitry (U2B and its inputs). The digital integrator produces a stepping frequency (RMPSTP and RTSTP) that is eight times greater than the fast axis

stepping frequency (FSTSTP). Frequency reduction of eight is performed by U1 and U2 on the Velocity Compensator card. RMPGATE is the RMPSTP frequency divided by three through U3 on the Velocity Compensator card. RMPGATE is used to clock the Acceleration/Deceleration Control circuitry. The integrator frequency (RMPSTP) is determined by the velocity value selected by the data selector (U18A). Either a Velocity Constant (U20) or the Velocity Register (U1 and U6) is selected for the velocity value. The Velocity Register provides the Digital Integrator (U2A and U4) with the acceleration/deceleration velocity profile. The Velocity Register also provides the data selector with a signal (TV) indicating that terminal velocity has been reached. The RMPDN signal from the Halfway Counter on the Data card is used by the Acceleration/Deceleration Control circuitry to determine when the plotter is to start the velocity deceleration profile. RMPDN goes high at the midpoint of a vector being plotted. The Variable Frequency Divider (U15 and U18, sometimes called a synchronous rate multiplier) uses the Quotient Register (U9 and U14) and the integrator frequency (via U3) to form the stepping frequency for the slow axis (SLWRTSTP reduced by eight to form SLWSTP).

### Digital Integrator

The plotter uses a digital integrator to produce pulses that control the velocity of the stepping motors. Fig. 6-14 illustrates a simple digital integrator consisting of a serial adder and two 4-bit shift registers. One register is an accumulator to which a constant or velocity value is added. The other contains the velocity. The number of clock pulses necessary to perform the binary addition is equal to the number of bits used in the registers. In the example the number is four. Note that the constant is recirculated and remains unchanged at the end of the addition while the accumulator is increased by the value of the constant. Successive additions cause the accumulator to overflow. This overflow pulse is sensed and becomes the integrator stepping frequency. With a larger constant being added, fewer additions are necessary to create an overflow, thus the stepping frequency is increased. In the velocity generation circuitry, an addition takes place every 10  $\mu$ s using a 16-bit accumulator, a 16-bit velocity register, and 16-bit hard-wired velocity constants.

Refer to the Velocity Generator schematic. The digital integrator is composed of adder U2A, accumulator U4, carry flip-flop U7A, and a data selector U18A that determines the velocity data source used. The velocity source may be a velocity constant generated at BCD decoder U20, or the velocity register (U6 and U1). The overflow carry from the integrating accumulator is provided by U7A and latched in a flip-flop delay line, U3. The RMPSTP frequency is divided by three on the Velocity Compensator card to produce RMPGATE. The RTSTP frequency is divided by eight on the Velocity Compensator card to produce FSTSTP. SLWRTSTP, which is discussed later, is divided by eight to produce SLWSTP.

### Velocity Generator Timing

Refer to the timing diagram of Fig. 6-15. Basic timing signals from the Timing card are CK, CK01, TA, TB, TC, TD, and T9. From these the TY,  $\overline{VCK}$ , and  $\overline{CK+CK01}$  signals are produced.  $\overline{CK+CK01}$  (output of U12B) is the inverse of the 2 MHz clock signal on the Timing card, partially compensated for gate delay times.  $\overline{VCK}$  is equal to  $\overline{CK01}$  appearing during plotter time T8.  $\overline{VCK}$  is used to latch the overflow carry from U7A into flip-flop delay line U3. It is also used to clock the RMPSTP frequency divider (U3) on the Velocity Compensator card that generates RMPGATE. TY has twice the frequency of TA and is used to generate constants on both the Velocity Generator and Velocity Compensator cards. It also provides timing to clock the velocity storage registers on the Velocity Compensator card.

### Velocity Values

Refer to the Velocity Generator schematic. The BCD decoder (U20) uses the plotter timing signals (Fig. 6-15) to generate constants used in velocity generation. Data selector U18A selects either a velocity constant generated directly at the BCD decoder or the output of the Velocity Register (U6 and U1). Serial binary numbers on the outputs of BCD decoder U20 have values of  $2^0$  on pin 1,  $2^6$  on pin 4,  $2^8$  on pin 5,  $2^{12}$  on pin 7, and  $2^{14}$  on pin 9. During the JRUN period preceding the RUN Sequence, the Velocity Register is preloaded with the value of  $2^8$  or 256. The output of the Velocity Register on line  $\overline{V32}$  is seen by the data selector U18A as having twice the register velocity. Thus the initial velocity value seen by the Digital Integrator during an acceleration sequence is 512, which corresponds to a pen velocity of 0.488 inches per second. The velocity selection criteria used is illustrated in Table 6-6.

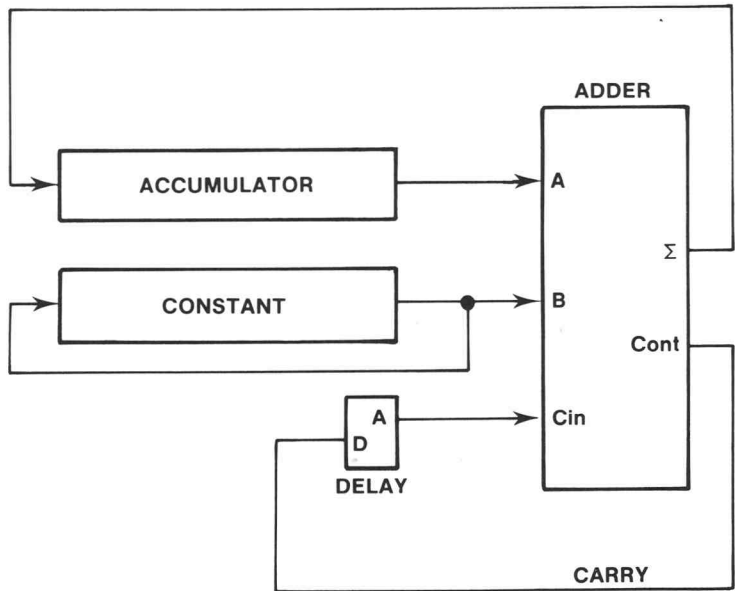
TABLE 6-6  
VELOCITY VALUES

Select Code	Function	Velocity	Binary Weight
B A			
1 0	Manual Move (fast)	3.91 ips	4,096 ( $2^{12}$ )
1 1	Manual Move (slow)	.061 ips	64 ( $2^6$ )
0 0	Accel/Decel ( $\overline{TV}$ )	.488 to 15.625 ips	512 to 16,384 ( $2^9$ to $2^{14}$ )
0 1	Terminal Velocity	15.625 ips	16,384 ( $2^{14}$ )

### Acceleration/Deceleration Control

The Acceleration/Deceleration Control circuitry on the Velocity Generator card determines the velocity profile (during acceleration and deceleration modes of plotter

DIGITAL INTEGRATOR  
USING SERIAL ADDITION

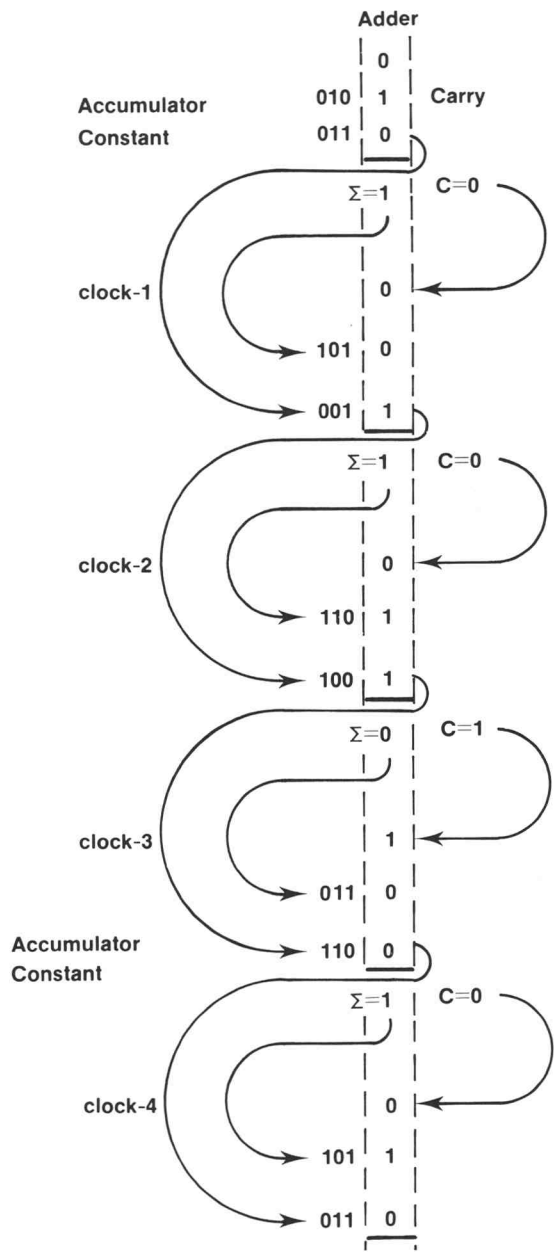


(a) Circuitry

Binary  
Addition

```
  0101
+ 0110
-----
 1011
```

(b) Example.



(c) Operation

1828-46

Fig. 6-14. Digital Integration.

pen movement) by performing the arithmetic that creates the velocity profile. It increments or decrements the velocity register (U1 and U6) in predetermined increments depending upon the state of the RMPDN signal. When RMPDN is low, the velocity register contents

increase in value and the pen velocity decelerates. When RMPDN is high, the velocity register contents decrease in value and the pen velocity decelerates. The RMPGATE signal determines when the Velocity Register is to be incremented or decremented.

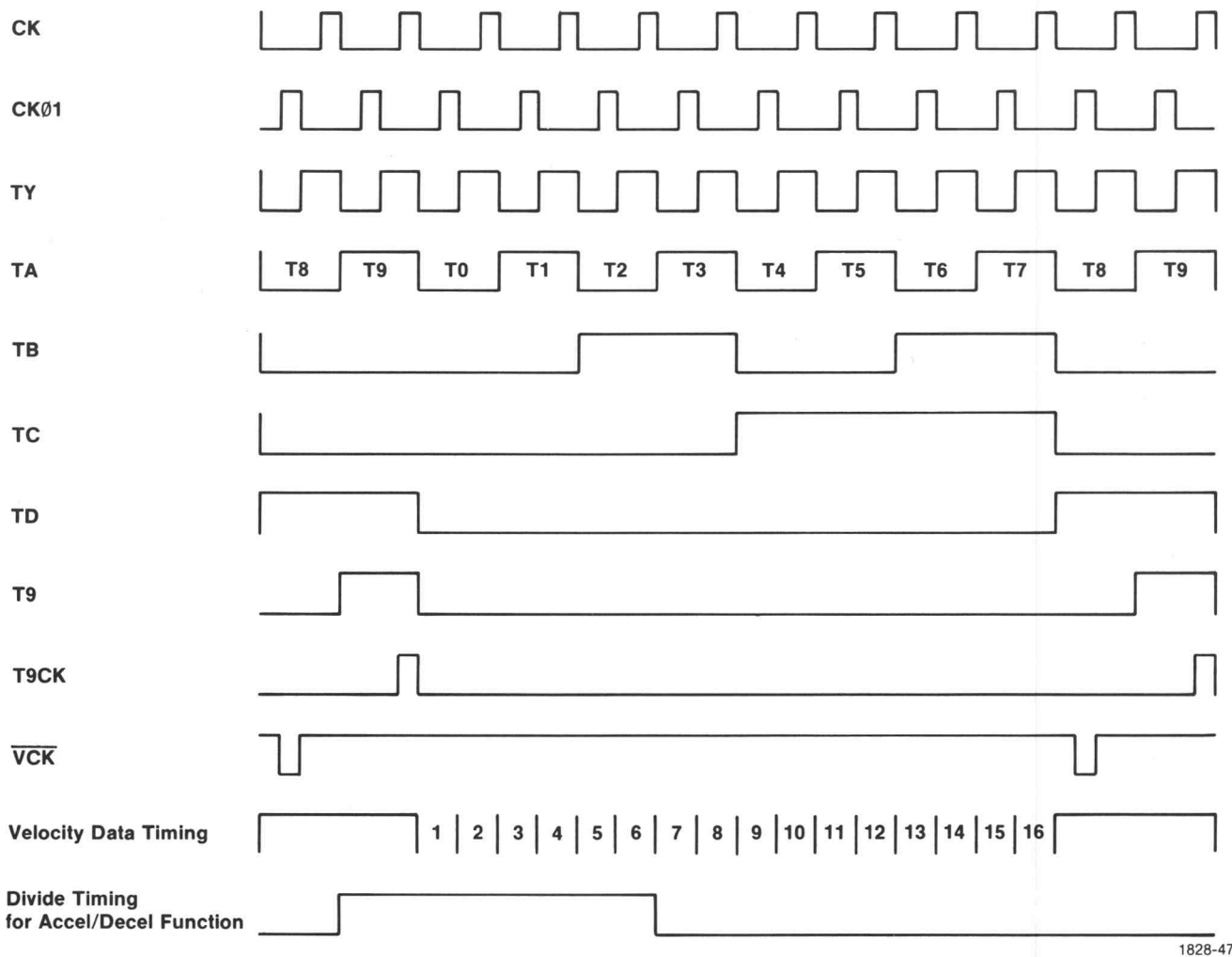


Fig. 6-15. Velocity Timing Diagram.

Refer to the Velocity Generator schematic. U6 and U1 comprise the 16-bit Velocity Register, which is used as an accumulator for the U2B full adder. The inverse of Velocity is stored in the Velocity Register. The velocity profile employed in the plotter resembles a sinusoidal function. The velocity profile is generated by iteratively performing the function:

$$V_{n+1} = V_n \pm \left( 1 + \frac{M - V_n}{C} : \text{integer} \right)$$

where

n = 0,1,2...indicating the iteration, the times the function is performed.

V<sub>0</sub> = Initial Velocity number of 256.

V<sub>n</sub> = Present value in the Velocity Register.

V<sub>n+1</sub> = Next value in the Velocity Register.

M = 8191, the working capacity of the Velocity Register.

C = 128, the divisor constant obtained by an effective right shift of the Velocity Register by 7 positions.

RMPDN (ramp down) determines whether a velocity increment is added to or subtracted from V<sub>n</sub>. The initial velocity value is equal to 256. The output of the Velocity Register on line  $\overline{V32}$ , as seen by the Digital Integrator, is twice the value of the Velocity Register contents because of an effective left shift. The left shift in velocity value is determined by the register output line used.

## System Description—4661 Service

Refer to the block diagram of the Acceleration/Deceleration Control (Fig. 6-16) and the Velocity Generator schematic. The divide timing for the acceleration/deceleration circuitry is controlled by U5A and U11C. The output of U5A is equivalent to plotter times T9, T0, T1 and T2, except when terminal velocity is asserted. The terminal velocity indicator (TV) is tied to the reset line of U5A. During the divide time (T9, T0, T1, and T2), the first 6 bits of a velocity data value are operated on — two bits per plotter T-time T0, T1, and T2. See the timing diagram Fig. 6-15.

The example in the block diagram shows the processing of the initial velocity value to obtain the next velocity value during the acceleration velocity profile. Fig. 6-16 uses the initial velocity value to illustrate the processing that occurs during the first RMGATE signal in a velocity acceleration sequence.  $M - V_0$  is obtained through the inverse of  $V_0$ . Divide by 128 is a right shift of 8 bits, resulting from the Velocity Register output on the  $\overline{V1}$  line. The  $\overline{V1}$  line is from pin 3 of U1. An initial carry is added via U18D. During RMPDN the initial carry is inhibited.

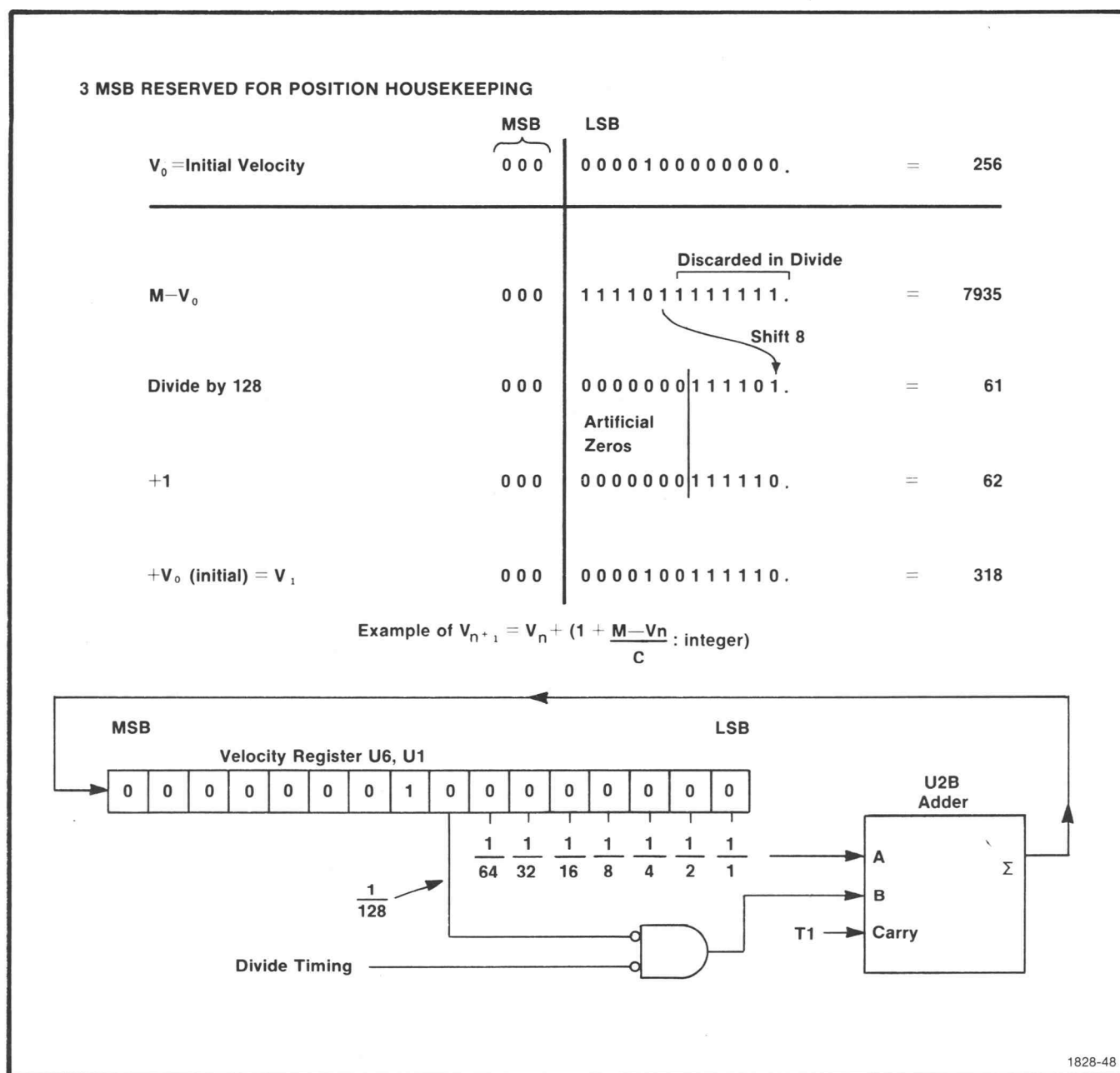


Fig. 6-16. Processing diagram for the acceleration/deceleration control.

When RMPDN goes high for the second half of a plotter vector, U13C complements the results of the division and U13A inhibits the initial carry. The result is a one's complement addition that results in a  $X - (Y + 1)$  subtraction synonymous to

$$V_n - \left( \frac{M - V_n}{128} + 1 \right)$$

Terminal velocity is sensed by U11A and latched into U3A by the VCK velocity clock signal. The terminal velocity signal (TV) causes the velocity selector U18A to select the terminal velocity value from U20, thus freeing the Velocity Register for position housekeeping activities. 600 RMPGATE signals are necessary to increment the Velocity Register from its initial velocity (256) to its terminal velocity (8192). Upon reaching terminal velocity, divide timing is disabled at U5A and the Velocity Register is incremented by one during each RMPGATE signal. If RMPDN is high, the Velocity Register is decreased by one for each RMPGATE signal until the Velocity Register becomes less than the terminal velocity. Then it is decreased according to the velocity functions.

### Velocity Calculations

During terminal velocity, the Digital Integrator creates one overflow pulse every 40  $\mu$ s. Since the integrator frequency (RTSTP) is divided by 8 on the Velocity Compensator card, a FSTSTP (fast axis stepping pulse) occurs every 320  $\mu$ s. Each stepping pulse (FSTSTP) at terminal velocity causes a pen movement of 0.005 inches, resulting in an axis pen velocity of 15.625 inches per second.

$$\frac{.005 \text{ in/pulse}}{.00032 \text{ sec/pulse}} = 15.625 \text{ ips}$$

RMGATE is equal to the integrator frequency (RMPSTP) divided by 3 on the Velocity Compensator card. Each RMPGATE signal is therefore proportional to the distance of pen movement. Fig. 6-17 illustrates the solution of the velocity function:

$$V_{n+1} = V_n + \left( \frac{M - V_n}{128} + 1 : \text{integer} \right)$$

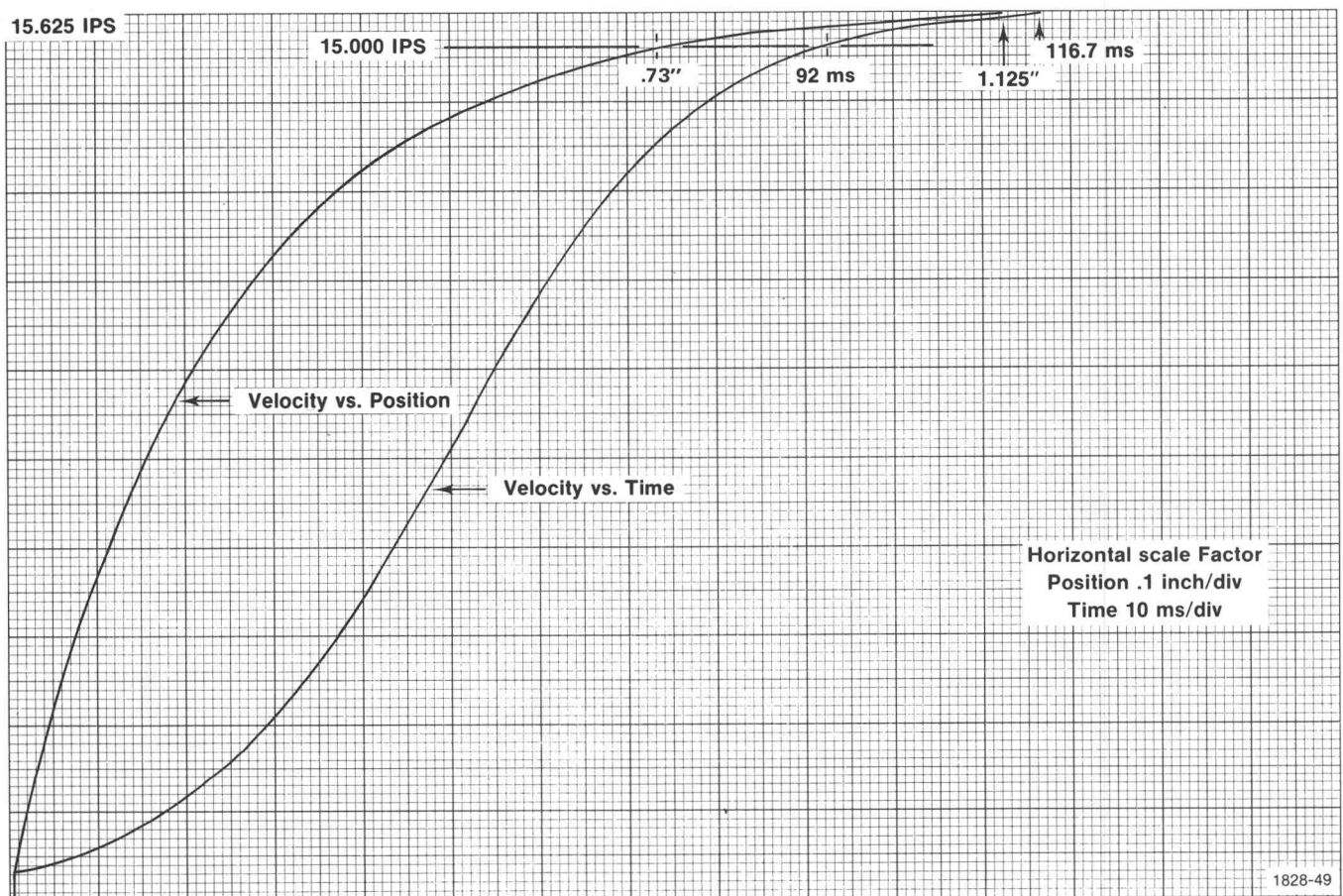


Fig. 6-17. Velocity Acceleration Profile of the Acceleration/Deceleration Control Function.

## System Description—4661 Service

The pen velocity is graphed with respect to pen position and with respect to time as the velocity function is incremented from initial velocity (256) to terminal velocity (8192).  $M$  is equal to 8191, the working capacity of the Velocity Register. Each iteration of the velocity function occurs during the RMPGATE signal. During acceleration and deceleration, the Digital Integrator uses a velocity value of twice the contents of the Velocity Register.

Refer to Fig. 6-18 illustrating pen movements of 2 inches and 3.375 inches. Graphed is the velocity profile (Velocity Register contents) with respect to position or RMPGATE iteration. Assume a move command of 2 inches, then 1 inch would be half of the axis delta. A 1 inch travel on acceleration consumes 533 RMPGATE modify iterations. At the halfway point of vector plotting, the RMPDN control signal reverses the process of velocity register modification from:

$$V_{n+1} = V_n + \left(1 + \frac{M - V_n}{C} : \text{integer}\right)$$

to

$$V_{n+1} = V_n - \left(1 + \frac{M - V_n}{C} : \text{integer}\right)$$

An additional 533 modify iterations of the Velocity Register are consumed in the process of deceleration, bringing the total number of iterations to 1066 for 2 inches of axis travel. Refer to Fig. 6-18 for a graphic representation.

For axis deltas in excess of 2.25 inches (greater than 1200 modify iterations), terminal velocity is reached. The Velocity Register is still incremented once for each RMPGATE signal, using the three most significant bits of the Velocity Register until the halfway point is reached. The same number of iterations used in going from the terminal velocity condition to the halfway point must be consumed after RMPDN goes high, to decrease the Velocity Register below the terminal velocity condition.

## Velocity Vectoring

To plot a vector, the stepping motors on each axis are often required to run at different speeds. The ratio of pen velocities (slow axis to fast axis) is loaded into the Quotient Register (U9 and U14) prior to a pen movement resulting from a calculator remote instruction. This quotient value is used by the Variable Frequency Divider (U10 and U15, sometimes called a synchronous rate multiplier) to produce the slower stepping frequency for the slow axis. Flip-flop delay line U3 provides a  $20 \mu\text{s}$  delay of the integrator frequency. Data selector U18B provides the SLWRTSTP signal, which has a frequency proportionately slower than the integrator frequency. SLWRTSTP determines the velocity of the slow axis. If the Quotient Register is equal to 1, QT00 is high and both the fast and slow axes share the same velocity. SLWRTSTP has a frequency equal to RTSTP, the integrator frequency, but SLWRSTP has a frequency equal to RTSTP, the integrator frequency, but SLWRTSTP lags RTSTP by  $20 \mu\text{s}$ . If the quotient register is zero, only one axis exhibits movement and SLWRTSTP never becomes activated.

The select inputs of U18 not only determine the velocity value used by the Digital Integrator, but also prevent the Quotient Register and Variable Frequency Divider from influencing SLWRTSTP during manual moves. During manual moves RTSTP and SLWRTSTP share the same frequency, but SLWRTSTP lags RTSTP by  $20 \mu\text{s}$ .

## VELOCITY COMPENSATION

Velocity compensation circuits provide the stepping motor circuits with binary values proportional to the axis velocities for generating motor operating voltages. Due to the inductive load exhibited by a stepping motor, an increase in velocity or stepping frequency requires a like increase in operating voltage if the motor is to track properly, i.e., move one increment of position for each stepping pulse.

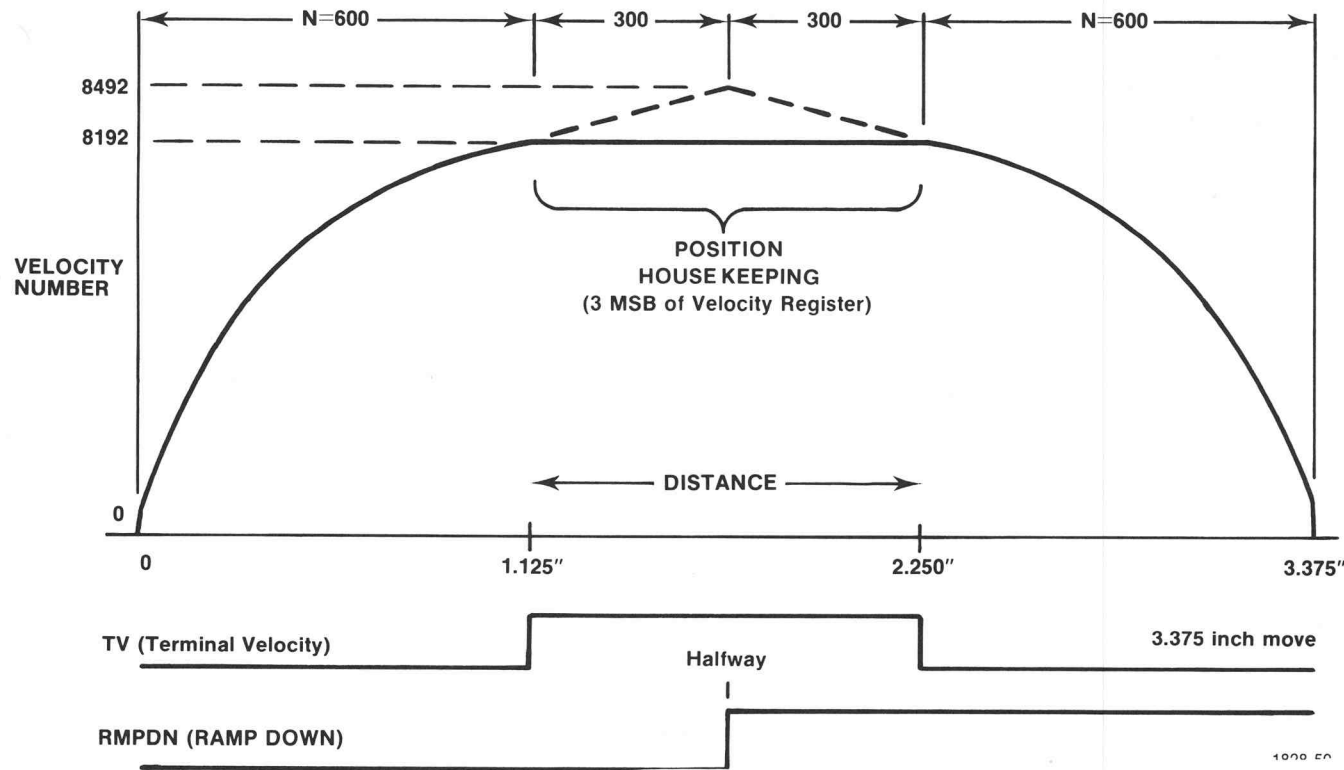
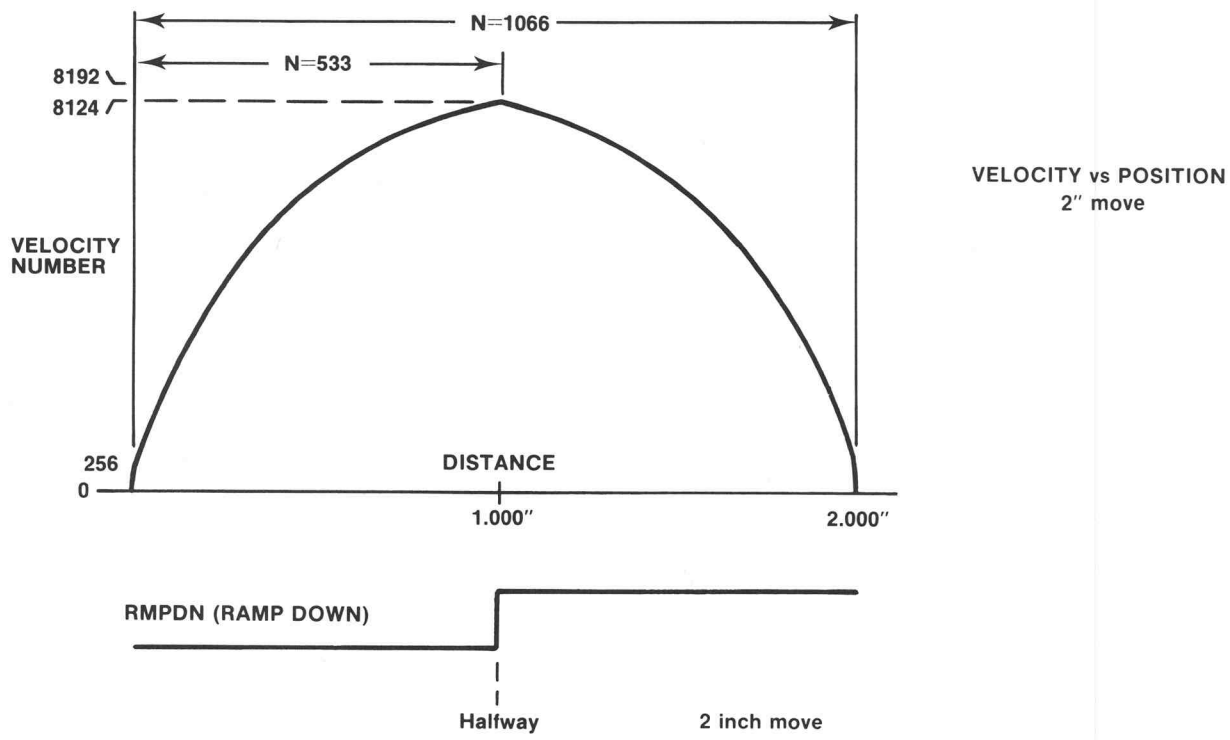


Fig. 6-18. Velocity vs Position for Axis moves of (a) 2 inches, (b) 3.375 inches.

## System Description—4661 Service

Refer to the Velocity Compensation block diagram Fig. 6-19, the timing diagram Fig. 6-20, and the Velocity Compensator Schematic. Most of the circuitry is located on the Velocity Compensator card. The Velocity and Quotient Registers on the Velocity Generator card provide velocity information and the ratio of axis travel. Velocity information from  $\bar{V}1$  is used by the Velocity Compensator card during T0, T1, and T2 and from  $\bar{V}32$  during T4, T5, and T6. Quotient information on lines VQ1 through VQ32 is used during T4, T5 and T6.

During T0, T1, and T2, a 6-bit velocity value, corresponding to the fast axis velocity, is serially loaded into the Multiply Register (U13) through two data selectors (U7A and U7B) and an adder (U14). During T3 Velocity Storage register (U16 or U20) corresponding to the fast axis is updated. The Multiply Register is then cleared. During T4, T5, and T6, the product of the Velocity Register and Quotient Register contents is placed into the Multiply Register. This corresponds to the velocity of the slow axis, which is then stored in the proper Velocity Storage

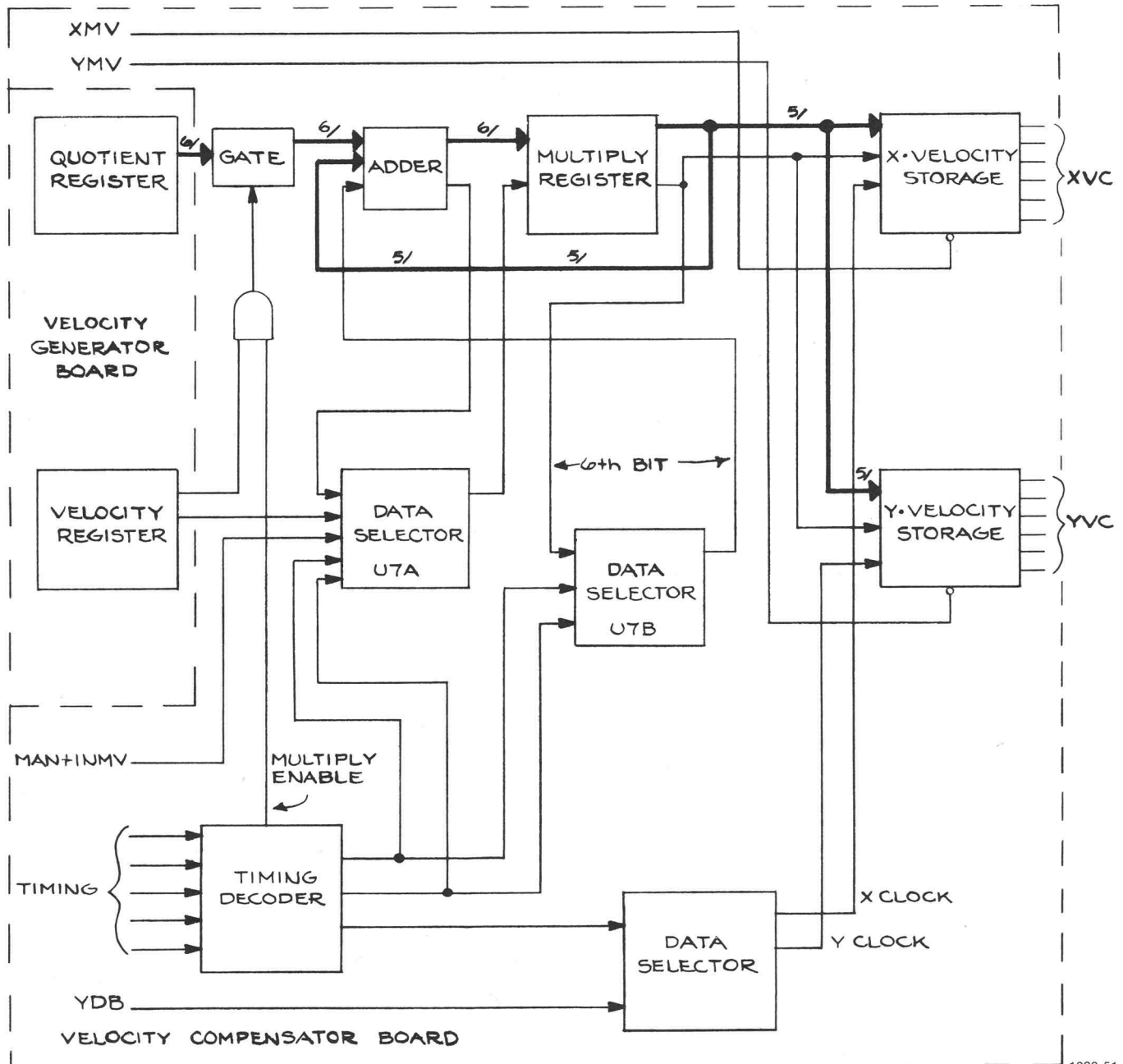
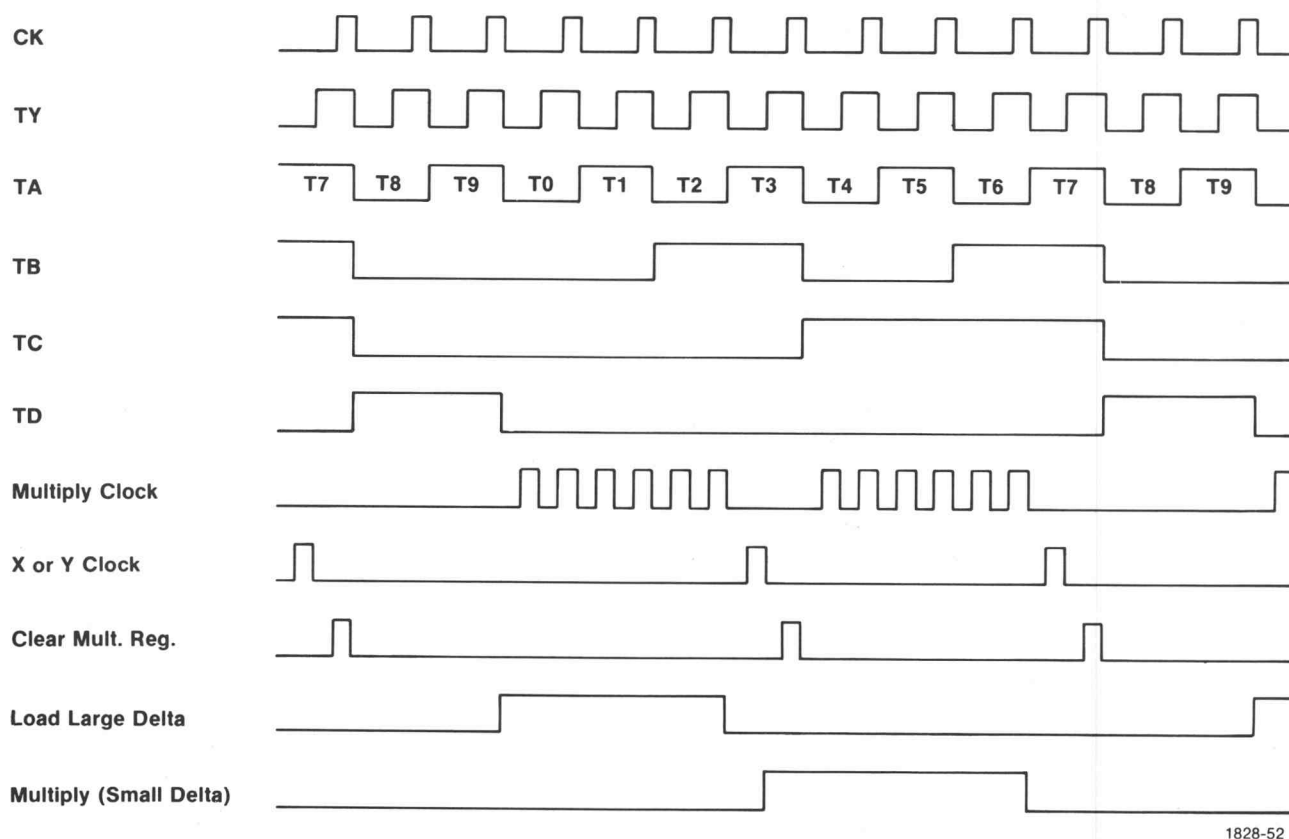


Fig. 6-19. Velocity Compensation Block Diagram.



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Fig. 6-20. Velocity Compensation Multiplier Timing.

register during T7. The Velocity Storage registers are enabled by XMV and YMV signals during an axis move. The registers are also reset at the completion of the move. Outputs of the Velocity Storage registers are used by the stepping motor circuits for voltage compensation. YDB, from the Data card, provides information as to which axis is fast or slow.

The least significant velocity data bit from  $\bar{V}1$  uses the following path as it is shifted to the end of the Multiply Register (U13) during T0, T1 and T2. The signal passes through the "0" input of U7A to input "6" of the Multiply Register. From here it is clocked to the output "6" of the Multiply Register. It then passes through input "0" of U7B to the "B4" input of the U14 adder. Since the "A" inputs of U14 are low, the "B4" signal becomes the sum signal at pin 15. This signal also resides at input "5" of the Multiply Register to be clocked to the output on the next clock pulse. The data then circulates through the adder to the input "4" position of the Multiply Register. Additional clock pulses shift the data bit to the output "1" position of the Multiply Register.

During T3, the contents of the Multiply Register containing the fast axis velocity are gated to the appropriate Velocity Storage register. The Multiply Register is then cleared by the output pulse from U6C.

During T4, T5, and T6, the 6 most significant velocity digits of slow axis velocity are calculated and loaded into the Multiply Register (U13). Calculation of slow axis velocity is a process of multiplying velocity quotient data and fast axis velocity. Refer to the example of Fig. 6-21 and the Velocity Compensator schematic. Fast axis velocity data arrives serially at  $\bar{V}32$ . Each time  $\bar{V}32$  goes low (velocity data bit of one), the velocity quotient data on lines VQ1 through VQ32 is added to the shifted contents of the Multiply Register. The result after six iterations is the six most significant digits of the slow axis velocity. During T7 the slow axis velocity is transferred to a Velocity Storage register. The Multiply Register is then cleared by a pulse from U6C.

During manual moves, constants generated at the data selectors (U7A and U7B) are used to load velocity data into the Multiply Register. The data is then transferred to the enabled Velocity Storage registers. The X Velocity Storage Register (U20) is enabled when XMV is high and reset when XMV is low. The same is true for the Y Velocity Storage Register (U16) and YMV. During a slow manual move, zeros are loaded into the Multiply Register. During a fast manual move, load move, or initial move, a 6-bit velocity number (21) is loaded into the Multiply Register. At terminal velocity the Multiply Register is loaded with ones.

Multiplication of velocity quotient  
and fast axis velocity  
equals the product (slow axis velocity)

MSB
LSB

$$\begin{array}{r}
 110011 \\
 \times 011011 \\
 \hline
 010101
 \end{array}$$

	Fast Velocity	Carry	MSB	LSB	
			0 0 0 0 0 0		Initial Multiply Register contents
LSB	1		+ 1 1 0 0 1 1		Add the quotient
		0	1 1 0 0 1 1		Sum
			0 1 1 0 0 1		Shift right (Multiply Reg.)
	1		+ 1 1 0 0 1 1		Add the quotient
		1	0 0 1 1 0 0		Sum
			1 0 0 1 1 0		Shift right (Multiply Reg.)
	0		+ 0 0 0 0 0 0		Add Zero
		0	1 0 0 1 1 0		Sum
			0 1 0 0 1 1		Shift right (Multiply Reg.)
	1		+ 1 1 0 0 1 1		Add the quotient
		1	0 0 0 1 1 0		Sum
			1 0 0 0 1 1		Shift right (Multiply Reg.)
	1		+ 1 1 0 0 1 1		Add the quotient
		1	0 1 0 1 1 0		Sum
			1 0 1 0 1 1		Shift right (Multiply Reg.)
MSB	0		+ 0 0 0 0 0 0		Add Zero
		0	1 0 1 0 1 1		Sum
			0 1 0 1 0 1		Shift right (slow velocity)

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Fig. 6-21. Multiplication.

The Timing Decoder (U11) is a BCD decoder that separates plotter timing signals TA, TB, TC and TD into their component T-times, T0 through T9. CK and CK01 regenerate a 2 MHz timing signal through NOR gate U17A. The timing diagram (Fig. 6-20) illustrates the relationships between timing signals and the functions they perform in the velocity compensation circuitry. The Multiply Clock (from U12A) is used by the Multiply Register (U13) to load the 6-bit velocity constants. The X or Y clock (from U10, U5B and U5D) is used to clock the X Velocity Storage Register (U20) or the Y Velocity Storage Register (U16). The Clear Multiply Register clock (from U6C) is used to return the Multiply Register to zero. Load Large Delta (T0, T1, T2) is the time during which the Velocity Register contents (fast axis velocity) is shifted into the Multiply Register. The multiply time (small delta) is when the slow axis velocity is calculated (T4, T5, T6).

Frequency division is accomplished with three binary counters. They are used to condition axis stepping frequencies for the fast and slow axes, and to generate a gating signal used to generate the velocity profile used in calculator initiated moves. These counters are U1 which generates FSTSTP, U2 which generates SLWSTP, and U3

which generates RMPGATE. U1 and U2 divide their input frequencies by eight. U3 divides its input frequency by three. The purpose of these counters is described in the Velocity Generation writeup.

### Etched Jumper Functions

These jumper functions are not to be changed. The jumper connections illustrated on the Velocity Compensator schematic as inputs to U7, are part of the etched copper on the printed circuit board.

Refer to the Velocity Compensator card component layout showing the jumper sets (Fig. 6-22). The etched straps illustrated can be found on the back of the printed circuit card. The front or component side of the circuit card is illustrated. The jumper indicated by A, B, and C, is used to determine the rate of pen acceleration and deceleration. The other jumpers determine the velocity compensation voltage used for fast manual moves.

Table 6-7 gives the acceleration time for the pen to move from zero to terminal velocity. The configuration yielding a 105 ms acceleration time is used by the plotter. Other configurations shown in Table 6-7 give the number of RMPSTP signals necessary to create one RMPGATE signal. Acceleration times for these configurations are also given.

**TABLE 6-7**  
**ACCELERATION TIME**

C B A	ACCEL/DECEL ms.	Frequency Division
1 1 1	35	1
1 1 0	70	2
1 0 1*	105	3
1 0 0	140	4
0 1 1	175	5
0 1 0	210	6
0 0 1	245	7
0 0 0	280	8

\*This jumper configuration is part of the etched copper on back of the circuit board.

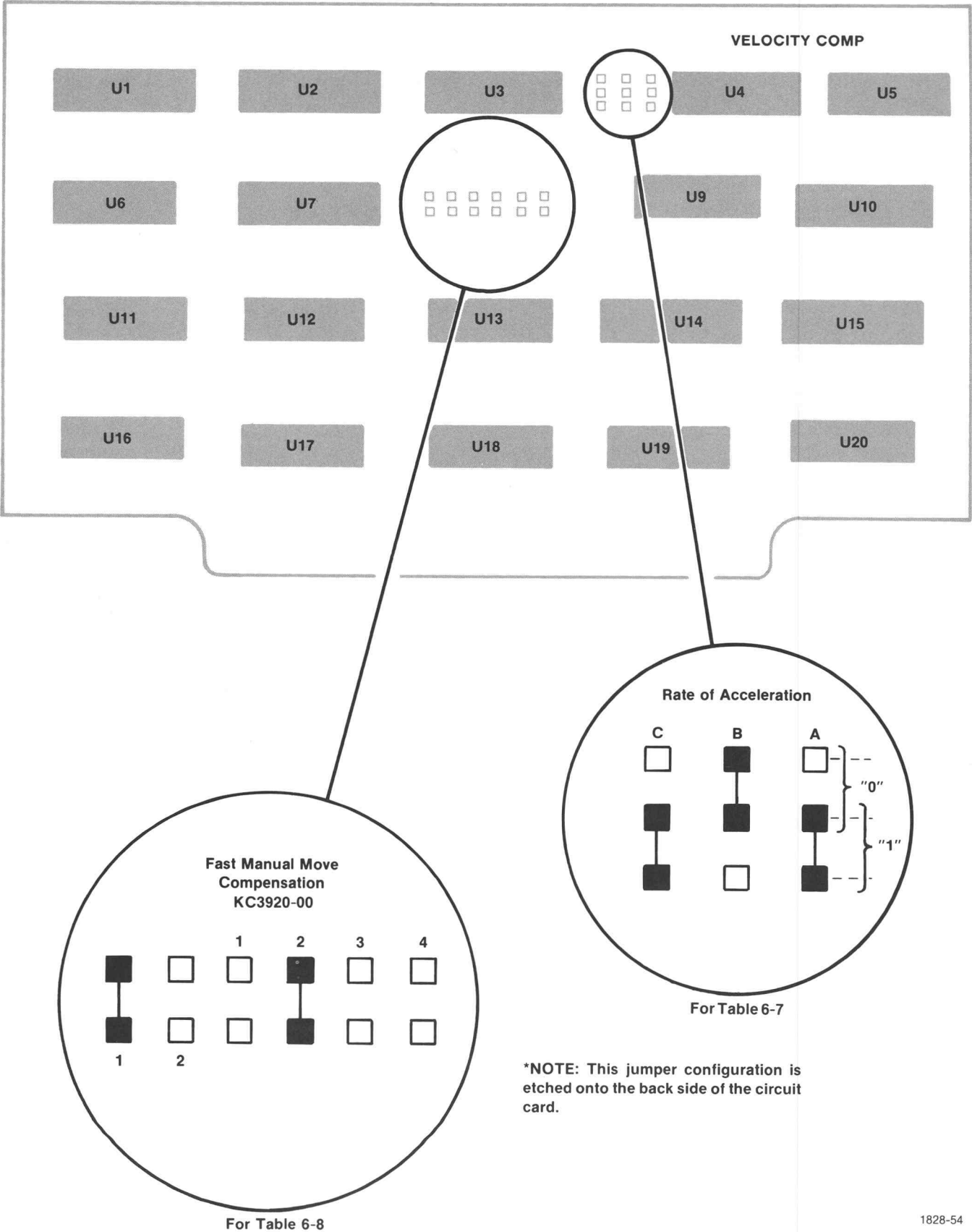


Fig. 6-22. Velocity Compensation Board.

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## System Description—4661 Service

Table 6-8 gives the jumper configurations and the velocity constants derived during a fast manual move, initial move, or load sequence. A velocity value of 21 is factory wired into the Velocity Compensator circuit card. Velocity constants generated using other jumper configurations are also tabulated. VC1 through VC32 are the output lines from a Velocity Storage register. Numbers in the mnemonics signify binary bit weighting.

**TABLE 6-8**  
**FAST MANUAL MOVE**  
**VELOCITY COMPENSATION**  
**CONSTANT**

Jumper Pins	Velocity Storage Register	Vel.
1 2 1 2 3 4	1 2 3 4 5 6	
1 0 1 0 0 0	1 1 1 0 0 0	7
1 0 0 1 0 0*	1 0 1 0 1 0	21
1 0 0 0 1 0	0 0 0 0 0 0	0
1 0 0 0 0 1	1 1 1 1 0 0	15
0 1 1 0 0 0	1 1 1 0 0 1	39
0 1 0 1 0 0	1 0 1 0 1 1	53
0 1 0 0 1 0	0 0 0 0 0 1	32
0 1 0 0 0 1	0 1 0 1 0 1	42

\*This jumper configuration is part of the etched copper on back of the circuit board.

## PLOTTER CONTROL CIRCUITRY

The plotter control circuitry controls the overall plotter activity. It sequences all the data processing activity and controls axis movement. Plotter control circuitry is located on the following cards:

Control	Board Location
Initial Program	Offscale card
Set Zero	Panel Interface card
Plotter Program	Program card and Axis Control card
RUN Sequence	Axis Control card
Axis Control	Axis Control card
Pen Commands	many cards

The Initial Program determines plotter activity that occurs immediately after the power to the plotter has been turned on. The Set Zero controls the arithmetic functions that load the Zero Memory with contents of the Position

Memory. The Plotter Program controls the data processing activity after a Y data instruction has been decoded and before an axis move occurs. The RUN Sequence controls the Position Memory and Delta Memory updating that occurs during pen movement along the X and Y axes. The RUN Sequence is discussed along with the Plotter Program. Axis Control determines which axis exhibits movement, also which axis is the fast or slow axis. Pen Commands are responsible for the lifting and lowering of the pen.

## INITIAL PROGRAM

The Initial Program starts automatically after power to the plotter is turned on and the power supply voltages rise to operating potential. Refer to the Initial Program Sequence (Fig. 6-23) and the foldout functional diagram of Initial Program circuitry (Fig. 7-11). The Initial Program is controlled by a row of flip-flops located on the Offscale card. Each flip-flop activates a specific function in the plotter circuits. This program establishes an initial zero position near the front left corner of the plotting surface (0.16 inch in from the front plotting boundary and 0.16 inch in from the left plotting boundary) by loading initial values into the Zero Memory registers ZX and ZY. The pen is then moved to the front right corner of the offscale plotting boundary, and the Position Memory registers PX and PY are updated with initial values reflecting the present pen position (the front right corner). Data manipulation periods are 10  $\mu$ s each. Axis movement periods are dependent upon the time necessary to complete the appropriate mechanical movement sensed by the closing of microswitches.

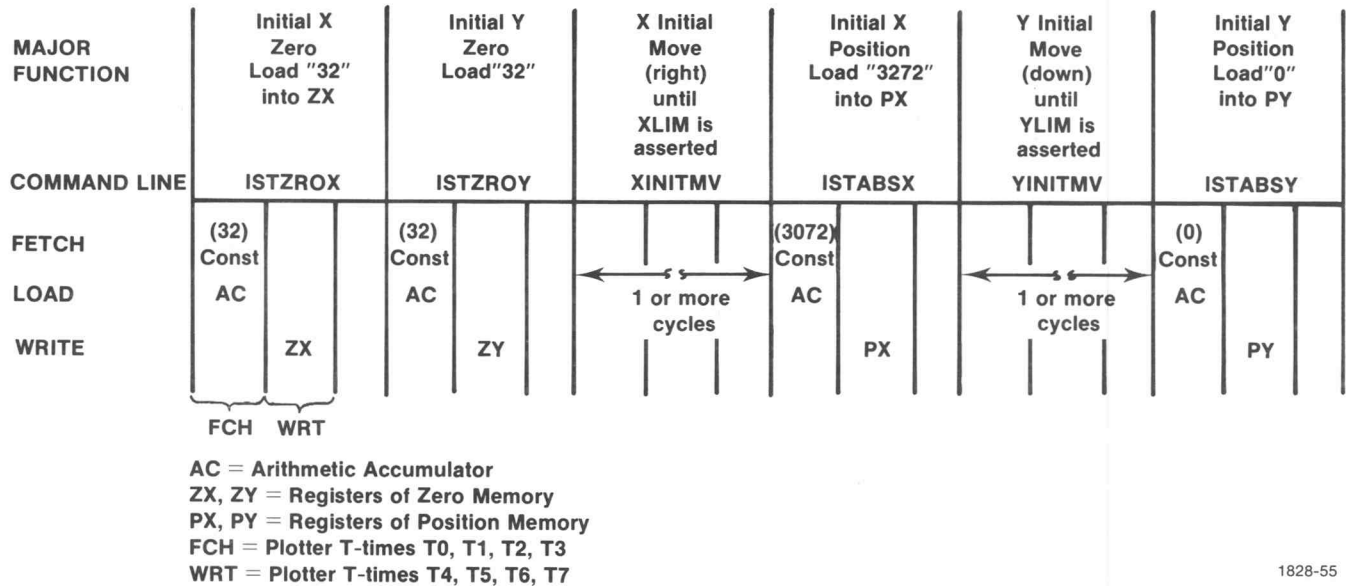
Refer to the Initial Program chart (Fig. 6-23) for the following discussion. The functional diagram (Fig. 7-11) is also helpful when relating to the circuitry involved.

During 1STZROX, a 10  $\mu$ s period, an initial value equal to 32 or 0.16 inch, where each increment is equal to 0.005 inch, is loaded into the ZX register of the Zero Memory.

During 1STZROY, the same constant (32) is loaded into the ZY register of the Zero Memory.

XINITMV activates the stepping motor controlling the X axis pen movement via the RUN Sequence on the Axis Control card. The Initial Program stays in the XINITMV state until the pen moves to the extreme right of the plotting surface and closes the XLIM switch. Pen movement stops when the XLIM microswitch closes and the Initial Program is allowed to continue to 1STABXS.

4661 INITIAL PROGRAM



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Fig. 6-23. Initial Program Sequence.

During 1STABSX, a 10  $\mu$ s period, the offscale constant (3072) representing 15.36 inches is loaded into the PX register of the Position Memory. This value represents the maximum value of X data and the right offscale plotting boundary (Fig. 6-24).

YINITMV activates the stepping motor controlling Y axis movement via the RUN Sequence on the Axis Control card. During YINITMV, the pen moves to the front offscale plotting boundary, closing the YLIM microswitch. The Initial Program remains in the YINITMV state until Y axis movement is complete and the closed microswitch causes the Initial Program to advance to 1STABSY.

The Initial Program then steps to the 1STABSY state, a 10  $\mu$ s plotter cycle. During 1STABSY, the number zero is loaded into the PY register of the Position Memory. This

value represents the front offscale plotting boundary. Upon completion of 1STABSY, the initial busy (INITBZ) flip-flop on the Program card is set, clearing the busy condition and enabling the calculator or the plotter panel switches to communicate with the plotter circuits.

Circuitry pertaining to Initial Program operation is located on the Offscale card, the Program card, the Timing card and the Data card. The functional diagram foldout of the Initial Program (Fig. 7-11) shows the information signals as they go from card to card. Logic of the signals during Initial Program execution is also shown and can aid in troubleshooting the plotter electronics. For clarity of presentation, logic that does not pertain to Initial Program execution has been deleted in the functional diagram. The Index of Signal Names in Section 5 is also helpful when using the Initial Program functional diagram as a troubleshooting tool.

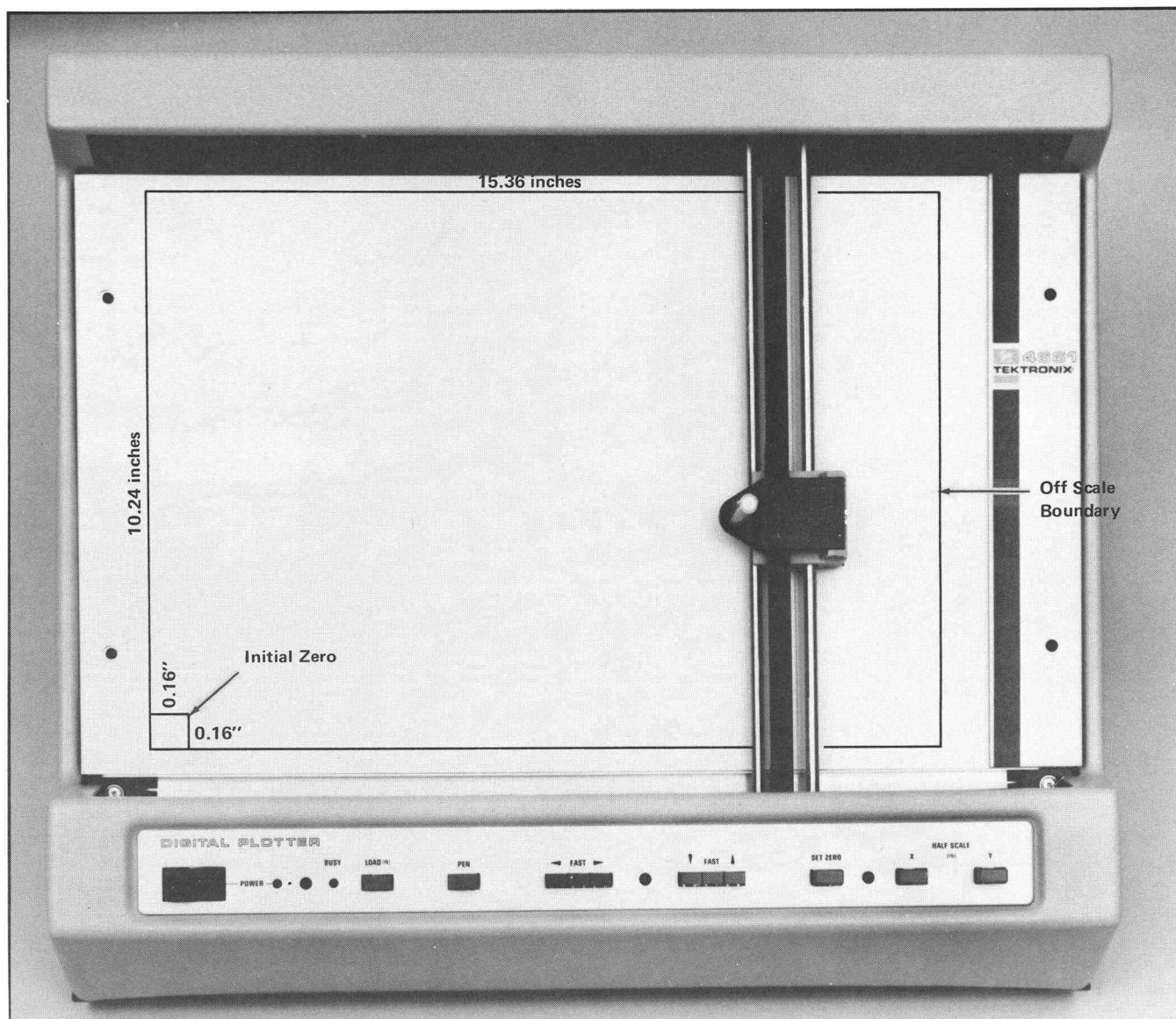


Fig. 6-24. Plotting Boundary and Initial Zero.

## PLOTTER PROGRAM

The Plotter Program provides the programming that controls the required data processing which must occur before a vector is drawn. Vectors are drawn from the present pen location to another pen location, which may be referenced to an arbitrary origin stored in the Zero Memory or the present pen location stored in the Position Memory. Refer to the Plotter Program foldout chart (Fig. 7-12) and the Program card schematic. The Plotter Program is composed of a row of flip-flops located on the Program card. The program is denoted by P00, P01, P02, ... and is initiated with a high JPROG signal on the Data Converter card. JPROG indicates that Y axis data from the Calculator Interface has been converted to binary and a vector is to be plotted.

Each Pxx (P00, P01,...) time lasts for 10  $\mu$ s, which is further broken down into 1  $\mu$ s T-times (T0 through T9). The first four T-times are denoted by FCH. FCH (fetch) is the time during which information (memory data or an offscale constant) is retrieved, arithmetic is performed, and the results are stored in the Arithmetic Accumulator. Addition, subtraction, and incrementing functions are the arithmetic functions performed at this time. Most arithmetic is performed by circuitry on the Data card, exceptions being offscale checking and velocity generation. Memory writing time, WRT, occurs during TC (T4, T5, T6 and T7). During WRT, the contents of the Arithmetic Accumulator may either be written into one of the memory registers or held in the accumulator. The two remaining T-times, T8 and T9, are for auxiliary functions such as enabling an extra shift for multiplying the Arithmetic Accumulator by two.

### Calculate X Position

When JPROG is high, the Plotter Program is initiated. P00 fetches new X data from the New Data Memory (NX register). This new data is a positive binary value. The sign information is provided by a sign bit on the XM line from Calculator Interface #1. XM stands for X minus. If XM is high, indicating negative X data, the two's complement of new X data is loaded into the Arithmetic Accumulator. Otherwise positive data is loaded. If the X HALF SCALE panel switch indicates a full-scale plotting condition (XFS is high), an extra shift is provided to multiply the accumulator contents by two during T9 of P00, thus converting the new X data from half-scale to a full-scale plotting value.

During P01, the next requested X position is calculated and the offscale limits for X are compared. The new X data, currently in the Arithmetic Accumulator, is added to either the position register PX or zero register ZX depending on whether the instruction sent by the calculator is for relative or absolute movement on the X axis. Relative movement is with respect to the last pen position and references the position register PX. Absolute movement is with respect to the established origin and references the zero register ZX. The control line XA (X absolute) from the Calculator Interface #1 card when high, causes the zero register ZX to be addressed, otherwise the position register PX is addressed. Calculation of the next requested X position takes place during FCH. At this time the sum is placed in the Arithmetic Accumulator and the small offscale condition for X is determined. During WRT the sum is written into the DX register of the Delta Memory and the large offscale condition for X is determined. During T9 of P01, the offscale boundary flags that indicate the data offscale conditions are loaded from the recirculating latch to the output register of the Offscale Status Latch on the Offscale card. The offscale boundary flags are  $\overline{XBG}$  indicating that position data is offscale to the right (or big direction) and  $\overline{XSM}$  indicating that position data is offscale to the left (or small direction). Detail description of offscale circuitry is found in the Offscale Comparison writeup.

The program cycle P02 fetches the next position data that was previously stored in the DX register unless an offscale condition exists. If an offscale condition is in the big direction as indicated by  $\overline{XBG}$ , the accumulator is loaded with a value equal to 3072 the maximum allowable limit for X data. If an offscale condition is in the small direction as indicated by  $\overline{XSM}$ , the accumulator is loaded with zeros, the minimum allowable limit for X data. The appropriate new X position is therefore loaded into the Arithmetic Accumulator during FCH. This data remains in the accumulator during the WRT period of program cycle P02.

During P03, the last X position (located in the PX register of the Position Memory) is subtracted from the new X position that is in the Arithmetic Accumulator to obtain the distance to be moved along the X axis. This distance is written into the DX register during WRT. Sign information indicating movement direction is stored in one bit of the Delta Sign Register, a 3-bit shift register on the Data card.

The position registers PX and PY, are updated incrementally during the RUN Sequence, which is activated later in the Plotter Program. The RUN Sequence is also activated during manual moves by control circuitry on the Axis Control card.

### Calculate Y Position

The same procedure that was used to calculate X position is carried out for Y data during P04, P05, P06, and P07. P04 fetches new Y data. P05 calculates the next requested Y position and tests the Y offscale limits. P06 retrieves the new Y position, taking into account the offscale conditions, and loads it into the accumulator. During P07, the last Y position is subtracted from the new Y position to obtain DY, the Y distance to be moved. This distance is stored in the DY register of the Delta Memory and the sign is shifted into the Delta Sign Register on the Data card.

### Prepare for Division

P08 retrieves the DX information from the Delta Memory and uses the sign of the delta information (direction of X axis movement) that has been stored in the Delta Sign Register to enter the absolute value of  $|DX|$  into the Arithmetic Accumulator. During the WRT period of P08, the absolute value of X axis movement  $|DX|$ , is written into the Delta Memory.

P09 calculates the absolute value of  $|DY|$  in the same way.

Program cycles P10 and P11 determine which axis has the farthest distance to move. During P10,  $|DX|$ , which is stored in the DX register of the Delta Memory, is loaded into the Arithmetic Accumulator. During P12, the subtraction  $|DX| - |DY|$  is performed to determine which axis has the larger distance to move. If the result is positive,  $|DX|$  is the bigger delta and has farther to move. The sign from the  $|DX| - |DY|$  operation is stored in the Delta Sign Register on the Data card to indicate which axis has the bigger or smaller movement.

## System Description—4661 Service

The information now stored in the Delta Sign Register is XDB meaning X delta is bigger than Y delta, YDB meaning Y delta is the bigger, XDP meaning X delta movement is positive or to the right, and YDM meaning Y delta movement is minus or toward the front of the plotting surface. XDB, YDB, XDP, and YDM are true when the voltages on their signal lines is near +5 V. If the signal voltages are near 0 V, their mnemonic meaning is reversed.

Program cycle P12 uses YDB, which is true if DY is bigger than DX, to load the bigger delta  $|DX|$  or  $|DY|$  into the Arithmetic Accumulator. During T4 of P12, a high flag bit is placed in the least significant bit (LSB) of the Quotient Register (QT15) on the Velocity Generator card. This flag is used to terminate the DIVIDE operation when it is shifted to the QT00 position. During T9 of P12,  $\overline{TK\Delta G}$  is asserted to load the Halfway Counter with a value such that an overflow occurs when the counter is incremented with the number of stepping pulses required to draw a vector to its halfway point. (The number of pulses required is half the value of the bigger delta.)

During program cycle P13, the smaller delta is fetched and placed into the Arithmetic Accumulator to prepare for the DIVIDE operation. The trailing edge of program step P13 also updates the Offscale Pen Control Register on the Program card. The DIVIDE operation uses the 16 steps from P14 through P29, causing the Quotient Register on the Velocity Generator card to take on the ratio of  $|smaller\ delta| / |larger\ delta|$ .

### Division

During the DIVIDE calculations YDB causes the bigger delta register to be added to or subtracted from the accumulator contents. The signs of DX and DY (located at XDP and YDM) determine the direction of motor travel and whether the PX and PY registers are incremented or decremented during the RUN Sequence.

Prior to DIVIDE, the accumulator is loaded with the absolute value of smaller delta and the Quotient Register is preset with QT15 high and QT14 through QT00 low. The DIVIDE routine provides a binary quotient  $|smaller\ delta| / |larger\ delta|$  by sixteen iterations of the 10  $\mu s$  sequence illustrated by Table 6-9.

**TABLE 6-9**  
**DIVIDE ALGORITHM**

T-Time	Function
1. T0 through T3	If QT15 is high, subtract the larger delta from the current accumulator contents, and hold the result in the accumulator. If QT15 is low, add the larger delta to the accumulator contents.
2. T4	At the end of CK01, shift the complement of the accumulator sign bit ( $\overline{ACS}$ ) into the least significant bit QT15 of the Quotient Register. ( $\overline{ACS} \rightarrow QT15$ )
3. T9	Multiply the contents of the accumulator by two.

DIVIDE terminates after the sixteenth iteration, one iteration after an initial high state is shifted from QT15 to QT00.

DIVIDE generates serially, a 16-bit binary quotient, with QT00 as the most significant bit (MSB). The bit weights for QT00 through QT15 are  $2^0, 2^{-1}, 2^{-2}, \dots, 2^{-15}$  respectively. Table 6-10 gives sample results of the DIVIDE routine.

**TABLE 6-10**  
**DIVIDE ROUTINE**  
**SAMPLE RESULTS**

INTERNAL REGISTER VALUES		QUOTIENT
Hexadecimal	Decimal Equivalents	Binary
		<div style="display: flex; justify-content: space-between;"> <span>QT00 (MSB)</span> <span>QT15 (LSB)</span> </div>
0019 <sub>16</sub> /0019 <sub>16</sub>	25/25 <sub>10</sub>	1. 000 000 000 000 000 <sub>2</sub>
0011/0022	17/34	0. 100 000 000 000 000
0004/0020	4/32	0. 001 000 000 000 000
0004/0021	4/33	0. 000 111 110 000 011
0001/0C00	1/3072	0. 000 000 000 001 010
0000/0C00	0/3072	0. 000 000 000 000 000
0000/0000	0/0	*1. 111 111 111 111 111

\*Special case, no movement.

Upon completion of the DIVIDE operation during P29, the Offscale Pen Register (Fig. 6-25) on the Program card is interrogated to see whether the pen is leaving the plotting boundary. During P30, or EARLY PEN, there is a 35 ms wait if the pen is to leave the plotting boundary while the pen is lifted or held high. If the pen is not leaving the plotting boundary, however, the EARLY PEN period is only 10  $\mu$ s long. No calculation that influences plotter performance takes place during this period whether it be 10  $\mu$ s long or 35 ms long.

## RUN Sequence

Refer to the RUN Sequence portion of the Plotter Program foldout diagram, Fig. 7-12.

JRUN is a 10  $\mu$ s cycle following the EARLY PEN period. The JRUN signal initializes the velocity generation circuitry on the Axis Control card. It also causes the Velocity Register on the Velocity Generator card to be preloaded with an initial velocity value of 256 or  $2^8$ .

During the RUN Sequence, the Axis Control card asserts control of the plotter. For each stepping pulse from the velocity generation circuitry, the Axis Control card executes a portion of the RUN Sequence that updates a delta register and a position register (DX or DY and PX or PY, depending on the axis being stepped). The Halfway Counter is also incremented during each fast axis stepping pulse (FSTSTP). The Axis Control card gating circuitry determines which axis uses the stepping pulses from the Velocity Generator. Fig. 6-26 shows the alignment of axis stepping signals. Upon receipt of JRUN and RUN signals, the Axis Control card generates XSTP1ST and XSTP2ND which perform X axis memory addressing and updating functions during X axis movement. XSTP, which is concurrent with XSTP2ND, is used to step the X axis stepping motor.

The Axis Control card also generates YSTP1ST and YSTP2ND, which perform Y axis memory addressing and updating functions during Y axis movement. YSTP, which is concurrent with YSTP2ND, is used to step the Y axis stepping motor. Each stepping motor runs at its own speed, determined by the frequency of the FSTSTP and SLWSTP stepping pulses. These are respectively the stepping pulses for the fast axis and slow axis. Additional information is included in the Axis Control writeup.

The following arithmetic takes place during the RUN cycle. XSTP1ST causes the value of the DX register to be decreased by one. XSTP2ND causes the value of PX to be advanced by one in the direction of pen movement along the X axis. STP1ST causes the value of DY to be increased by one. YSTP2ND causes the value of PY to be advanced by one in the direction of pen movement along the Y axis. The RUN Sequence repeats until DX and DY have been counted down to -1. The RUN Sequence is also asserted during manual moves via the control circuitry on the Axis Control card.

## Post Processing

After the RUN Sequence completes, control returns to the Program card for post processing unless a manual move was just performed. In this case, plotter activity ceases until another command or instruction is given. Refer to the Plotter Program foldout chart. The 10  $\mu$ s JPOST period interrogates the Offscale Pen Register (Fig. 6-25) on the Program card to enable the pen to lower if it has entered the plotting area.

The LATE PEN period causes a 35 ms wait to allow the pen to drop to the plotting surface if it has entered the plotting area. Afterwards, the plotter releases the busy condition ( $\overline{\text{PLBY}}$ ) via the RUNEN signal and waits for another command or instruction.

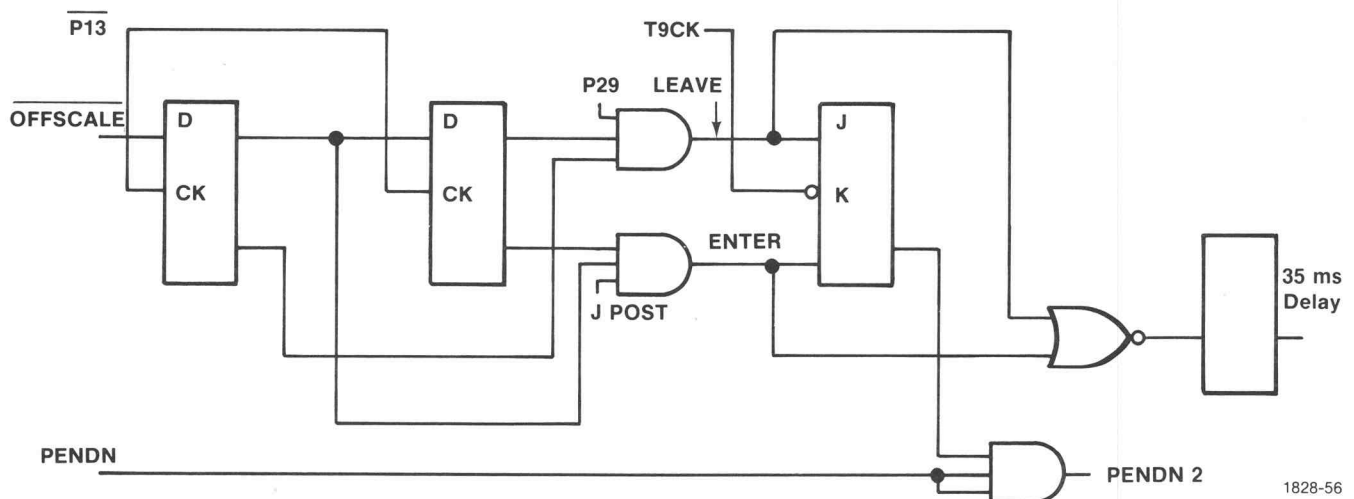


Fig. 6-25. Offscale Pen Register.

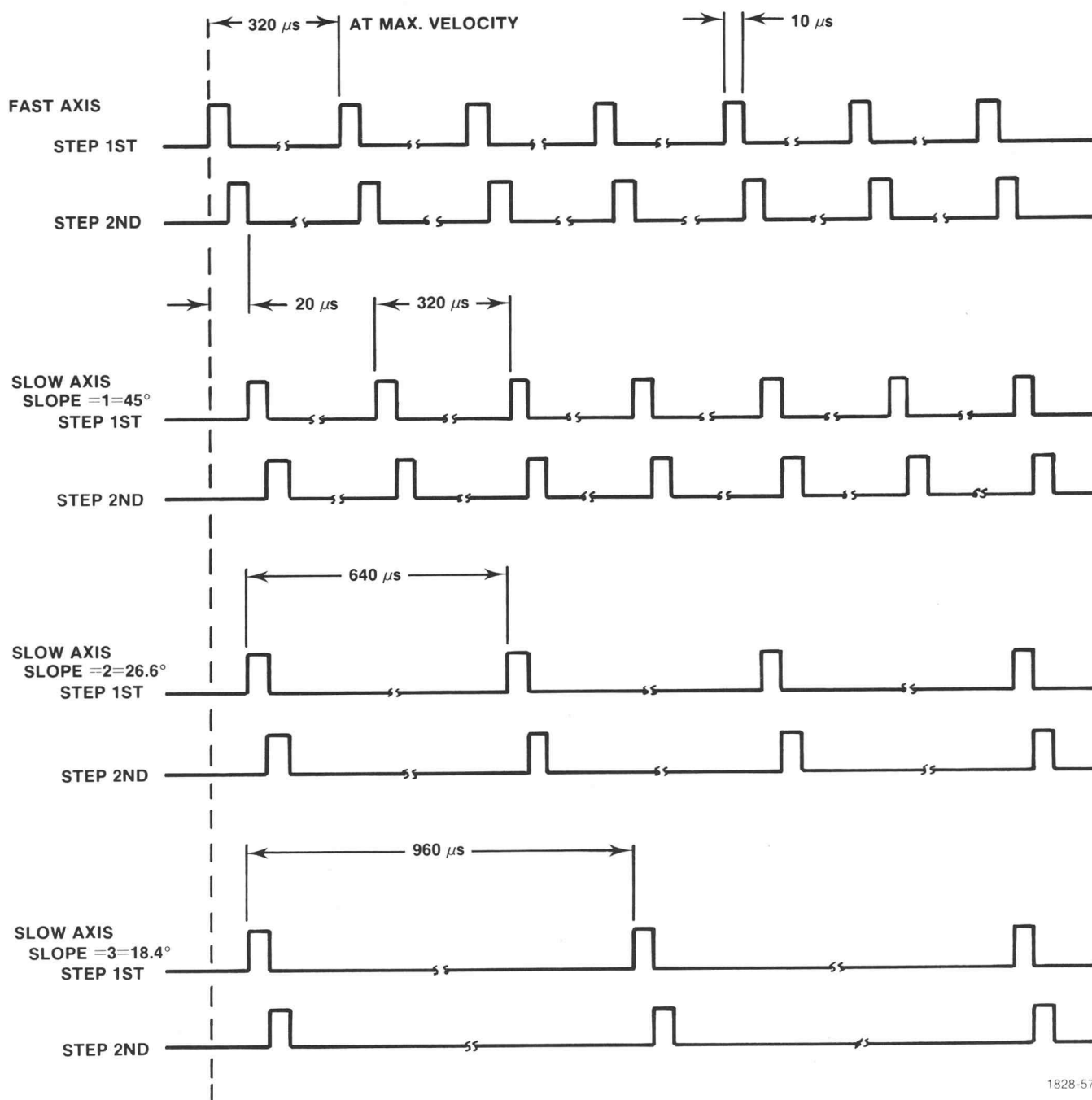


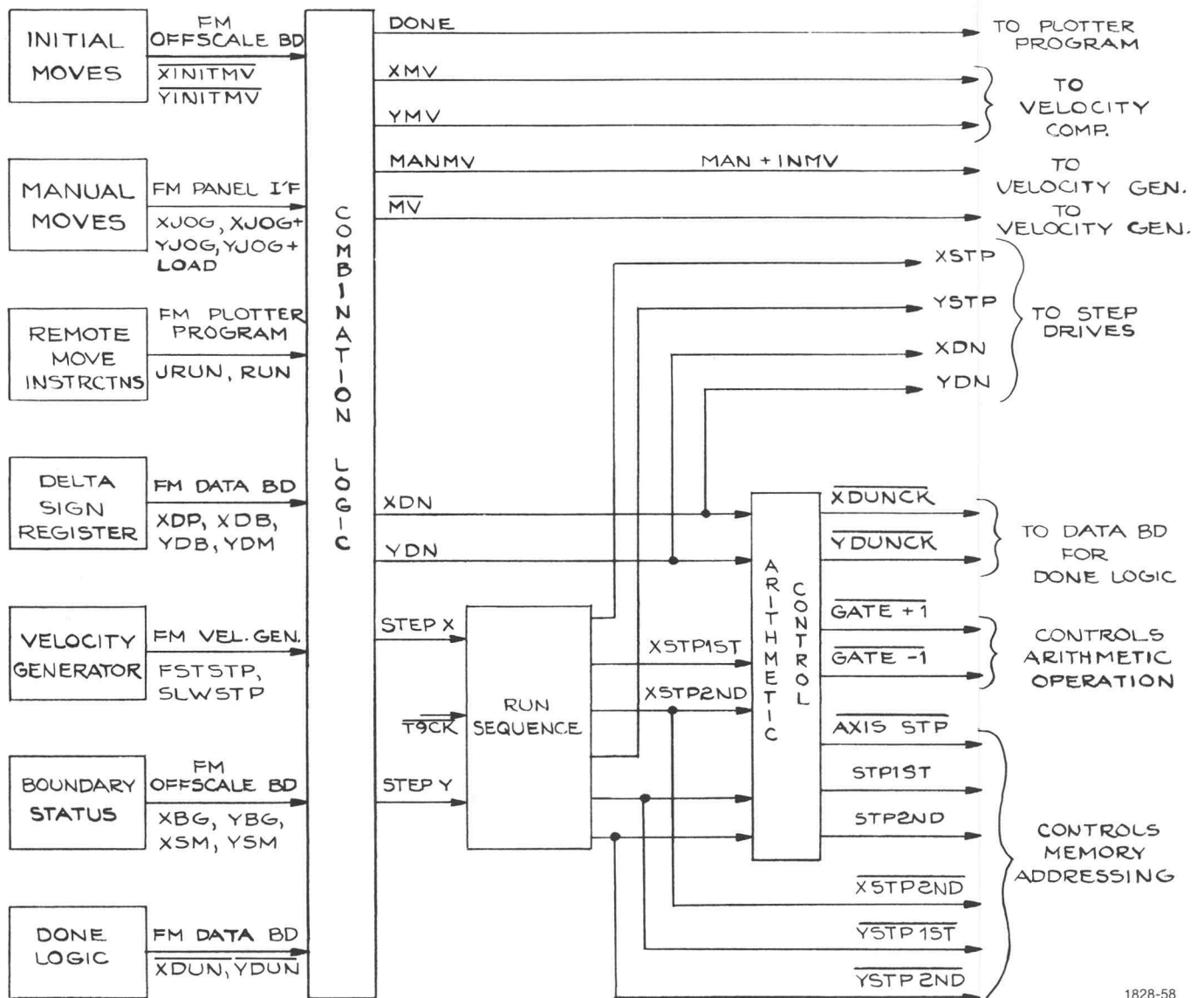
Fig. 6-26. Alignment of STP1ST and STP2ND during the RUN sequence.

## AXIS CONTROL

Axis Control circuitry uses the axis move commands to channel velocity stepping pulses to the appropriate Step Drive circuits. Included on the Axis Control card are the RUN Sequence flip-flops that provide timing and control for arithmetic operations. Refer to the Axis Control block diagram (Fig. 6-27) and the Axis Control card schematic. Additional information regarding arithmetic activity of the RUN Sequence flip-flops is presented in the Plotter Program writeup.

## Input Lines

The initial move commands  $\overline{XINITMV}$  and  $\overline{YINITMV}$  cause the equivalent of fast manual moves in the X axis (to the right) and in the Y axis (toward the front). These commands are asserted by the Initial Program located on the Offscale card. The Initial Program is described in detail elsewhere. The Initial Program controls plotter activity during initial power-up operation and in plotter restart operation.



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Fig. 6-27. Axis Control Block Diagram.

Manual moves are asserted by decoded signal lines from the plotter panel switches which are used for manual pen positioning. Signal lines XJOG and YJOG indicate manual movement in the X axis and Y axis. XJOG+ indicates manual movement to the right if high, to the left if low. YJOG+ indicates manual movement away from the front if high, toward the front if low. LOAD asserts a manual movement to the right along the X axis. The Panel Interface writeup and schematic describe the generation of JOG signals.

Remote move instructions are initiated by the Plotter Program after the calculator has initiated a remote command and entered Y axis data. Axis motion is initiated by JRUN and continues to be asserted as long as RUN is high. For details concerning plotter data processing activity, refer to the Plotter Program writeup.

The Delta Sign Register is located on the Data card. It is updated with each execution of the Plotter Program resulting from a calculator initiated move. Signal lines from the Delta Sign Register indicate the direction of axis movement and which axis has the greater distance to move. XDB and YDB are the logical inverse of each other. XDB when high, indicates that the X axis has farther to move than the Y axis. When YDB is high, XDB is low and the Y axis has farther to move. Direction of calculator initiated moves is indicated by XDP and YDM. If XDP is high, the X axis movement is positive to the right. If YDB is high, Y axis movement is minus or toward the front.

The velocity generator circuits issue FSTSTP and SLWSTP indicating fast axis stepping frequency and slow axis stepping frequency for calculator initiated moves. For manual moves, FSTSTP triggers the RUN Sequence for

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the X axis, creating XSTP, XSTP1ST, and XSTP2ND. During remote move instructions (calculator initiated) the fast axis is determined by contents of the Delta Sign Register indicating which axis has the greater distance to move.

Boundary status indicates the status conditions of the plotting boundary limits.  $\overline{XBG}$  or  $\overline{YBG}$  is asserted if the pen is at the big plotting boundary of the X or Y axis (right or back).  $\overline{XSM}$  or  $\overline{YSM}$  is asserted if the pen is at the small plotting boundary of the X or Y axis (left or front). These signals indicate a respective offscale condition as sensed by the Offscale card.

Done Logic is located on the Data card and senses the signs of the Delta Memory registers DX and DY during pen axis movement. The signs of DX and DY are latched using the signals  $\overline{XDUNCK}$  and  $\overline{YDUNCK}$ .  $\overline{XDUN}$  and  $\overline{YDUN}$  bring this sign information to the Axis Control card. When high,  $\overline{XDUN}$  and  $\overline{YDUN}$  indicate that DX and DY have been counted down to -1 or lower and that axis movement has been completed. DX and DY indicate distance to be traveled by the pen in the X and Y axes. DONE is asserted when both  $\overline{XDUN}$  and  $\overline{YDUN}$  are low. DONE is used to return plotter control to the Plotter Program on the Program card upon completion of axis movement.

### Combination Logic Outputs

Outputs of the Combination Logic provide inputs to the Plotter Program, Velocity Compensator card, Velocity Generator card, RUN Sequence and to the Step Drives. DONE returns control to the Plotter Program. XMV and YMV allow voltage compensation signals from the Velocity Compensator card to be made available to the Step Drives operating the stepping motors. MANMV goes to the Program card where it becomes MAN+INMV. MAN+INMV and MV control velocity selection on the Velocity Generator card. XDN and YND indicate that the pen position is to be incremented in the down direction. If XDN is high, pen movement is to be toward the left. If YDN is high, pen movement is to be toward the front. STEP X and STEP Y are the inputs to the RUN Sequence at flip-flops U13A and U12A respectively. See the Axis Control schematic.

### RUN Sequence

The RUN Sequence operation is also discussed in the Plotter Program writeup. It provides the program control necessary for the arithmetic activity used to update the Delta Memory and Position Memory during pen axis movement. Outputs of the RUN Sequence flip-flops are used in the following manner:

XSTP	Is used to increment the state of the X axis stepping motor.
------	--

YSTP	Is used to increment the state of the Y axis stepping motor.
XSTP1ST	Adds -1 to the contents of DX.
XSTP1ST	Adds -1 to the contents of DY.
XSTP2ND	Adds $\pm 1$ to the contents of PX depending upon XDN.
YSTP2ND	Adds $\pm$ to the contents of PY depending upon YDN.

### Arithmetic Control

Some of the arithmetic control logic affiliated with the RUN Sequence is located on the Axis Control card. Both the Axis Control block diagram (Fig. 6-27) and the Axis Control schematic are helpful references. The arithmetic control logic is combinatorial logic using outputs of the RUN Sequence flip-flops.  $\overline{GATE+1}$  and  $\overline{GATE-1}$  are generated to add one or subtract one from memory data during memory updating periods.  $\overline{GATE+1}$  influences an initial carry bit via the Timing card.  $\overline{GATE-1}$  influences the accumulator data lines on the Data card.  $\overline{AXISSTP}$ , nd YSTP2ND are gated on other boards to provide memory addressing for the RUN Sequence.

$\overline{XDUNCK}$  and  $\overline{YDUNCK}$  are asserted during T4CK01 and gated by XSTP1ST.  $\overline{XDUNCK}$  and  $\overline{YDUNCK}$  cause the sign bits of DX and DY to be latched into flip-flops, creating the axis completion signals  $\overline{XDUN}$  and  $\overline{YDUN}$ .

## PANEL INTERFACE

The Panel Interface enables the operate to communicate with the plotter electronics by means of the plotter panel switches. Operation of the panel switches is as follows.

### POWER Switch

A rocker switch for applying power to the plotter electronics and step drive motors. It also initiates a power-up restart sequence described in the Initial Program writeup and the Power Supply writeup.

### POWER Indicator

A light-emitting diode (LED) that monitors the +5 V supply and indicates the presence of power to the plotter.

### BUSY Indicator

A LED that indicates the plotter is busy, during which time the panel switches are disabled and have no effect. It goes on when the pen is raising or lowering, when the plotter is in the load mode for loading paper and when the plotter is in communication with the calculator. The busy circuits disable plotter keyboard operations. BUSY stays on for an additional 1 second after the completion of remote command processing. (It is not asserted by X data commands, Remote 31 and Remote 35.)

### LOAD Switch

A locking, push-button switch to allow loading paper into the plotter. When the button is depressed, the pen lifts and the 880 V supply to the electrostatic paper hold down is turned off. The plotter goes off line after the last remote instruction entered via the calculator has been processed; at which time the pen carriage moves to the far right margin. The LOAD button, when depressed, disables all other control functions and causes the BUSY light to be on.

### PEN Switch

A pushbutton switch that changes the state of the Pen State Register when pressed. If the pen is down, it will be lifted, and vice-versa. The switch has no effect when the plotter is busy. If the last move to the plotting boundary was the result of a remote command, the pen state register will change state, but the pen will be prevented from lowering to the plotting surface.

### Manual Move Switches

The X manual move switches are a set of three push-button switches that cause horizontal pen movement. Depressing an outer switch by itself moves the pen carriage slowly to the left or right. Pushing the center switch in conjunction with either of the outer switches causes a fast move to the left or right.

The Y manual move switches are another set of three push-button switches which cause Y axis movement. Pushing either of the outer switches moves the pen slowly along the Y axis. Pushing the center button in conjunction with one of the other buttons increases the rate at which the pen moves.

The manual move switches are disabled when the plotter is busy. Pressing both the outer switches in an axis prevents movement in that axis.

### SET ZERO Switch

A push-button switch that causes the X and Y zero coordinates (plotting origin) to be set at the present pen position. This button is disabled when the plotter is busy.

### HALF SCALE (X & Y) Switches

Two locking push-buttons (one for each axis) that cause plotting in the half-scale mode when depressed. Any combination of half-scale and full-scale operation for both the X and Y axes is allowed. The conditions of the HALF SCALE switches will only be asserted when the plotter is not busy. Changing the state of these switches during a busy mode will not affect the scaling of X and Y movement.

### Panel Interface Circuits

For the following discussion of Panel Interface operation, refer to the Panel Interface card Schematic. The panel switches connect and disconnect the +12 V dc power supply to and from the signal lines appearing on the connectors P3 and P4. Resistor packs R10 and R15 (along with buffers U5, U14, and U20) help to eliminate switching transients. The LOAD switch, PEN switch and SET ZERO switch use the debounce logic to trigger U1B, a 35 ms one-shot multivibrator. If these switches are pressed and released before a 35 ms time, multivibrator U1A is also triggered, holding the plotter busy for one second. Calculator remote commands (except for those transferring X data) trigger U1A (a one second one-shot multivibrator), which inhibits panel switch activity for one second after a remote instruction is execute.

### Manual Move

The manual move circuits provide plotter control signals referenced to the T9CK clock pulse. The manual move switches for the X and Y axes provide the information source for manual moves. The XJOG and YJOG signals indicate manual moves in the X and Y axes. XJOG+ and YJOG+ indicate manual movement in the positive direction — right for the X axis and toward the rear for the Y axis. JOG SLW, when high, indicates a slow manual move. These signals are decoded representations of the manual mode switch positions referenced to the T9CK clock.

The U19 flip-flops are cleared upon receipt of a busy signal via pin 1, thus preventing manual movements when the calculator is controlling plotter activity. The clock pulses are also inhibited by U2B when the plotter is busy. The JOG signal goes true for manual moves, but not load moves or initial moves. When both the JOG and OFFSCALE signals are true, pen state register U9E removes the PENDN condition, thus lifting the pen. When both JOG and OFFSCALE are true, it indicates that the pen is given a more command while on the offscale plotting boundary.

## Debounce Logic

There is debounce logic on the Panel Interface card used by the PEN, SET ZERO, and LOAD switches. Signals derived from these switches entering the Panel Interface card are PEN, ZERO, LDSW, and PZL, which come directly from switch contacts. The switches are "break before" make. Debounce signal DB is normally low, which causes the output of U11A (a strobed NOR gate) to remain high.

When either of the three switches is pressed, the PZL line goes high. If the plotter is not busy, flip-flop U9A becomes set at the next T9CK clock. When the debounce signal goes high the 35 ms one-shot multivibrator U1B is triggered. If the debounce signal disappears before U1B times out (which happens if PEN, SET ZERO, or LOAD switches are pressed and released within 35 ms) U1A will trigger and keep the plotter busy for an additional one second.

U1B creates a 35 ms pulse that sequentially sets U8A and U8D. U8A and U8D are likewise sequentially reset upon completion of the 35 ms pulse. The AND gates U12A and U12B provide timing strobes for pen state data (via U12A) and for initializing the load move sequence (via U12B). U12C prevents the debounce logic from becoming active when the plotter is busy.

## Pen Commands

Pressing the PEN switch causes the pen state flip-flop U9E to change state. The PEN switch activates the debounce logic, causing data multiplexer U4A to accept inputs on pins 3 and 4. U3A inverts the PENDN signal, which is accepted by U4A during a high output from U12A (see Fig. 6-28), this changing the state of U9E at the T9CK clock. Afterwards, pen state flip-flop U9E remains unchanged (because the output of U12A is low) until U1B is again triggered and creates another 35 ms pulse.

Remote pen commands are started by  $\overline{JPEN}$  initiating the 35 ms pulse from U1B. This 35 ms pulse causes the pen state flip-flop to be updated by the  $\overline{PROGUP}$  line during the output of U12A (see Fig. 6-28). If  $\overline{PROGUP}$  is high, the PENDN command goes high and the pen lowers. If  $\overline{PROGUP}$  is low, the PENDN command goes low and the pen lifts. The 35 ms pulse also triggers U1A and causes plotter busy ( $\overline{PLBY}$  and  $\overline{BUSY}$ ) to be asserted.

## Set Zero Commands

A set zero command causes the Zero Memory to be located with the contents of the Position Memory. The Zero Memory is located on the Offscale card. The Position Memory is located on the Data card. The process of information transfer involves the arithmetic unit controlled by  $\overline{ZROFF1}$  and  $\overline{ZRO2}$  signals via the Timing card and Offscale card. Timing for the  $\overline{ZROFF1}$  and  $\overline{ZRO2}$  signals is represented by Fig. 6-29. Between each T9CK clock pulse while  $\overline{ZROFF1}$  is low, data is fetched from the Position Memory (during FCH) and is written into the Zero Memory (during WRT).  $\overline{ZROFF1}$  causes the Position Memory to be addressed while fetching position information and the Zero Memory to be addressed while writing information. Plotter busy, PLBY, is also asserted.  $\overline{ZRO2}$ , when low, addresses Y axis data; otherwise X axis data is addressed.

Pressing the SET ZERO switch activates the debounce logic and initiates the set zero command. The ZERO switch line from the SET ZERO switch, is interrogated by U4B during the output of U12A (see Fig. 6-28) for starting the 30  $\mu$ s timing sequence signaled by  $\overline{ZROFF1}$  and  $\overline{ZRO2}$ .

The Remote command from the calculator causes the PRZO line from Calculator Interface #1 to go high. This signal is interrogated by U4B to initiate the set zero command sequence, during which  $\overline{ZROFF1}$  and  $\overline{ZRO2}$  are activated.

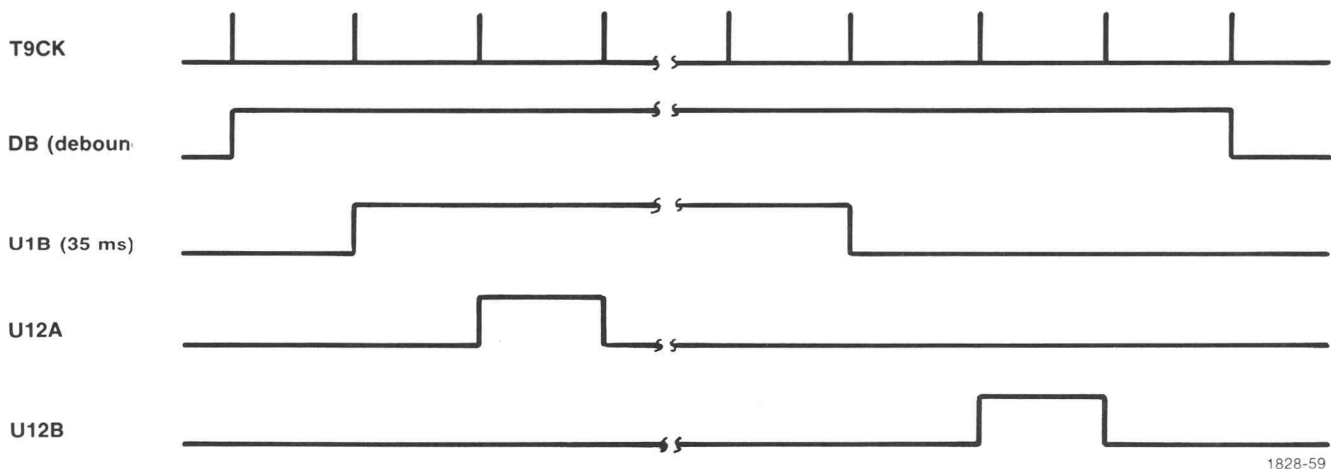
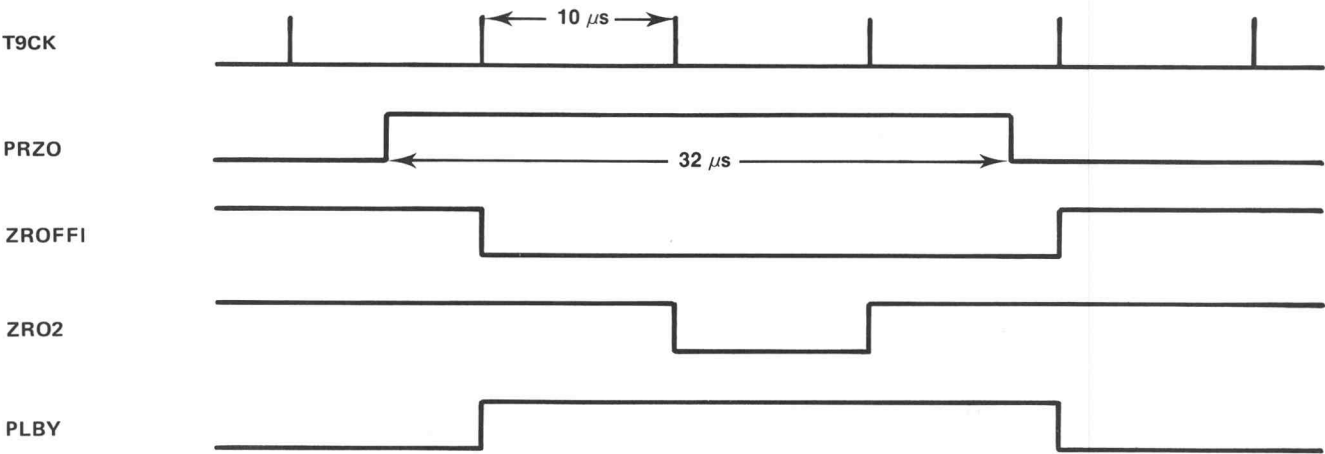


Fig. 6-28. Debounce Timing. T9CK is a 10  $\mu$ s clock, DB is the debounce signal from U9A. U1B is the 35 ms one-shot multivibrator. U12A strobes the next state of the pen state register U9E. U12B initiates a LOAD move if the LOAD switch is depressed.



	X Data				Y Data				X Data			
Memory Function		FCH	WRT		FCH	WRT		FCH	WRT			
Memory Register		PX	ZX		PY	ZY		PX	ZX			

FCH = Fetch Data (plotter timer T0, T1, T2, T3)  
WRT = Write Data (plotter timer T4, T5, T6, T7)  
PX, PY = Registers of Position Memory  
ZX, ZY = Registers of Zero Memory

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Fig. 6-29. Set Zero Command Timing.

## LOAD Move

Pressing the LOAD switch removes the PENDN condition to cause the pen to lift, and it disconnects the +12 V dc from the CHART on line to turn off the 880 V electrostatic paper hold. LDSW and the LDSW connections to the LOAD switch are asserted. The LDSW signal at P3-7 acts through U2A to disable the inputs to U4A, causing the pen to lift. The PENDN signal will go low and the pen lifts even though the plotter has not finished the move in process. Pressing the LOAD switch activates the debounce logic via PZL after the plotter finishes execution of the last remote instruction. The plotter also goes off line. Refer to the debounce timing diagram, Fig. 6-30. The debounce logic triggers U1B, creating a 35 ms timing pulse. This pulse sequentially sets U8A and U8D, thus creating a 10  $\mu$ s pulse at the output of U12A. U8A and U8D are sequentially reset upon completion of the 35 ms pulse and create a 10  $\mu$ s pulse output from U12B. The 10  $\mu$ s pulse output from U12B initiates a LOAD move signal, causing the pen carriage to move to the rightmost margin and close the XLIM switch. The LOAD move signal is output from flip-flop U9C when triggered by the U12B output, if the LOAD switch is pressed (causing LDSW at P3-7 to be low) and the XLIM signal is low.

## STEP DRIVE

The Step Drive cards convert rate pulses, direction signals and binary velocity values into electrical impulses

that operate the stepping motors. These electrical impulses are translated into mechanical motion by the stepping motor when the motor coil sets are excited singularly or in pairs as indicated by the excitation sequence of Fig. 6-31. Refer also the block diagram of the Step Drive circuits (Fig. 6-32) and the Step Drive Schematic.

## State Counter

The state counter consists of digital counter U3 and a state decoding network consisting of U1, U2, and U4. The digital counter determines the state signal while the decoder provides the motor drive information to the bridge amplifiers. The state counter is clocked by the T9CK clock pulse during a STP (step) command. Another signal (DN), when asserted, causes the state sequence to count down instead of up. Refer to Fig. 6-31 for the excitation sequence.  $\pm$  indicates the direction of current through the motor windings.

## Compensation

Since the motor load is inductive, the motor coil current will decrease with an increasing step rate unless compensation is employed. A 6-bit digital-to-analog converter (DAC) converts a 6-bit velocity value to a voltage level ranging from 5 V to 25 V depending on the velocity value. Further compensation of the stepping motor is required

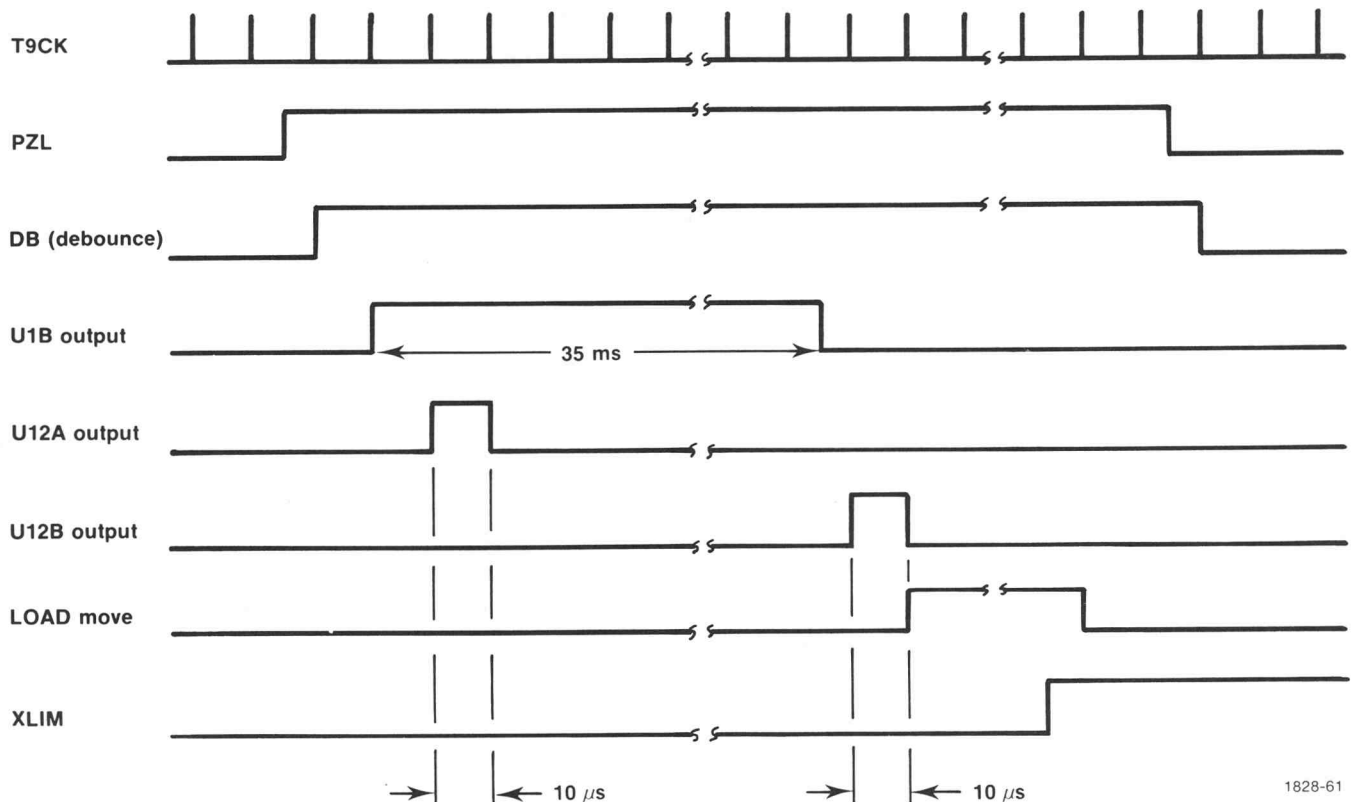


Fig. 6-30. Load Operation Timing.

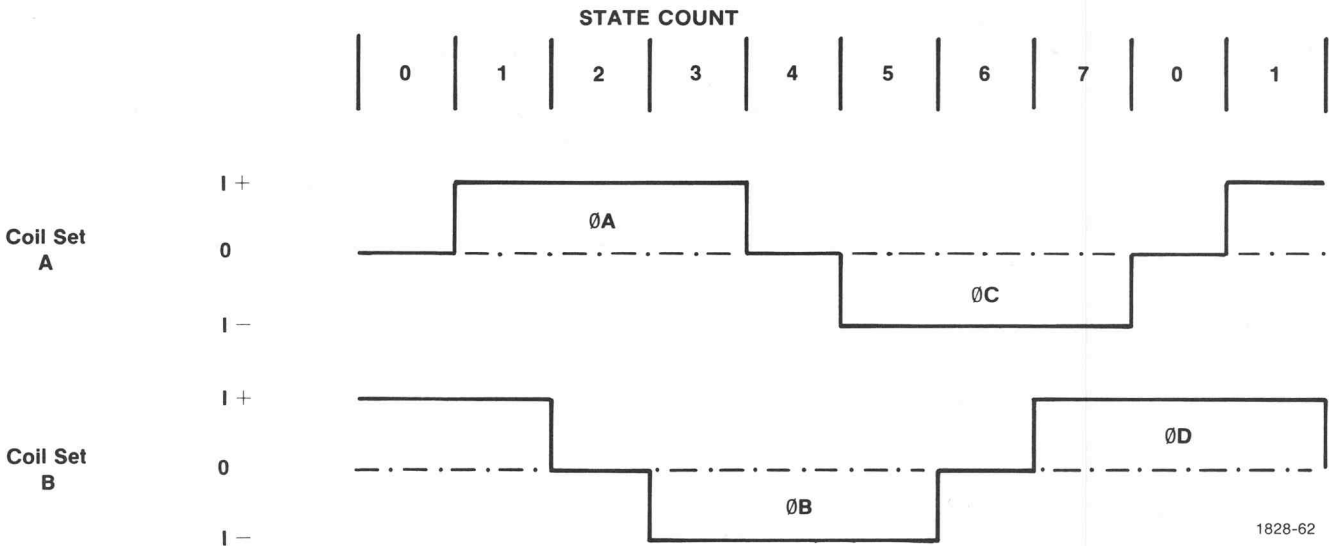


Fig. 6-31. Stepping motor excitation sequence for clockwise rotation, or rotation in the positive direction with respect to the X or Y axis. For rotation in the negative direction, the state count is counted down from right to left.

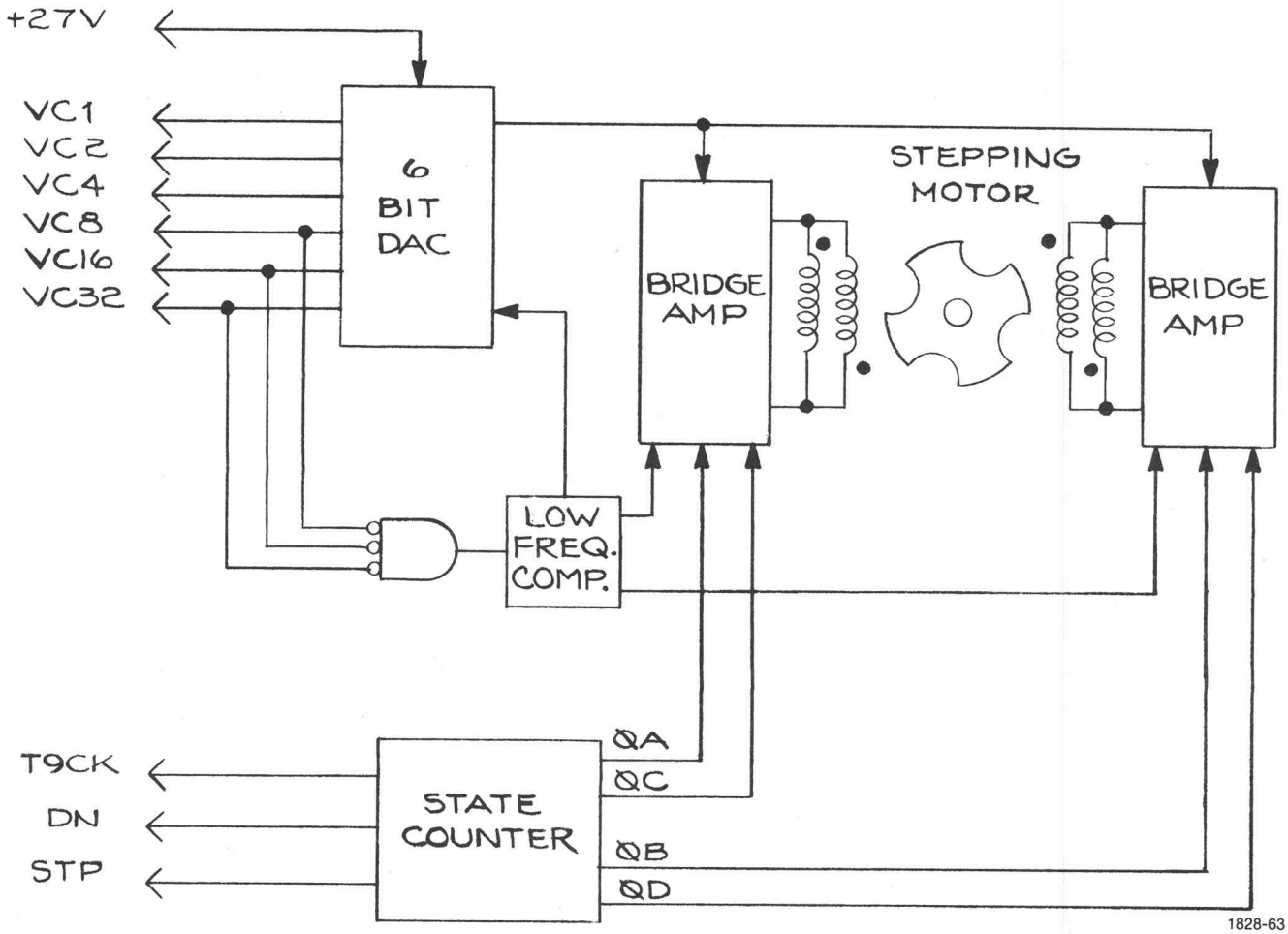


Fig. 6-32. Step drive circuits block diagram.

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for velocities below 1.74 ips. As the drive sequence alternately excites one, then two motor coils, the non-uniformity in time-to-position of a step command is controlled by modulating the drive supply voltage and by shorting the dormant motor coil at velocities below 1.74 ips.

### Six-bit DAC

The DAC provides the voltage used by the stepping motors. An inverting amplifier (Q12, Q11 and Q5) referenced to the +5 V logic supply control series pass amplifier element Q101 to provide a regulated voltage (to the bridge amplifiers) that is proportional to the binary velocity number. The bridge amplifiers drive the motor coils. The current developed by U7 through the binary weighted resistors must be offset by the 1 k $\Omega$  feedback resistor. To offset the generated current, the drive supply voltage will be 25 V when all control inputs are logic 1. Logic 0's on all inputs result in 5 V for drive supply except when the low frequency compensation is active. Current limiting is provided by Q6, protecting Q1010 (X axis) or Q1020 (Y axis) for long term shorts and the bridge amplifiers for short term shorts.

### Low Frequency Compensation

The state counter output (U3 pin 3) is examined by U4 for a condition in which two coils are energized. The modulation of the drive supply voltage (a 20% reduction if two coils are on) is active for velocities below 1.74 ips, which improves stepping motor dynamics for low velocities by reducing overshoot. The voltage reduction takes place via resistors on the base of Q11.

### Bridge Amplifiers

The bridge amplifiers apply the appropriate drive voltage to the stepping motor coils. Drive voltage is provided by the DAC circuits. Signals from the low frequency compensation logic and the state counter control the application of motor drive impulses.

A bridge amplifier drives current through an analog switching arrangement to a set of stepping motor windings. It does this by means of transistor switches on the power ground (Q17, Q18, Q19, and Q20) and transistor switches on the driving voltage (Q13, Q14, Q15, and Q16) output of the DAC. Diode bridges D5 and D6 suppress back emf from motor coils to protect the power switching transistors.

Current source Q3 provides level-shift amplification to turn on transistors Q15 and Q20, thus causing current to pass through Q15, coil set A, then through Q20 to ground. Only one side of each bridge amplifier is active at one time. Current sources Q1, Q2 and Q4 operate the same as Q3. During low frequency compensation, Q9 and Q10 cause

Q19 and Q20 to ground both sides of coil set A if the coil set is inactive. Q7 and Q8 likewise cause Q17 and Q18 to ground coil set B. Grounding the coils prolongs the magnetic field decay time in the motor coils, thus improving motor dynamics at low velocities by minimizing position overshoot.

## POWER SUPPLY

The Power Regulator Board provides the power supplies necessary for plotter operation. It also provides an initial power-up restart signal,  $\overline{RST}$ , which initializes plotter activity immediately after the power supplies have reached operating voltage levels. Refer to the Power Supply schematic for the following discussion.

The cooling fan is connected across primary windings of the transformer. It therefore receives an operating voltage near 110 V ac by an autotransformer effect if the plotter is wired to accept other line voltages from other power sources. For changing line voltage compatibility (operation at voltages other than 110 V ac) refer to the Installation writeup in Section 1.

The unregulated power lines entering the Power Regulator Board are +27 V dc, -27 V dc and +8 V dc using full-wave bridge rectification with center-tap return. The +27 V dc line is used by positive Pen Solenoid supply, the unregulated +12 V dc supply, and the stepping motor circuits via pins T, U, and V. The -27 V dc line is used by the negative pen solenoid supply. The +8 V dc line provides power for the regulated +5 V dc supply.

There is voltage dependence between the voltage regulating circuits in the plotter power supply. The +27 V dc supply has to rise above 13 V dc to establish the 12 V dc power supply voltage. The +5 V dc supply voltage uses the regulated +12 V dc voltage to provide the voltage reference used to regulate the +5 V dc supply. Both the +12 V dc and the +8 V dc supplies have to be established before the +5 V dc voltage stabilizes. The +12 V dc supply is connected to the CHART ON line by releasing the LOAD switch on the plotter control panel. The 880 V electrostatic hold down voltage is established using a class C blocking oscillator. The  $\pm 27$  V dc supplies are used by the pen solenoid.

### 12 Volt Supply

The regulated +12 V dc supply uses a 9.1 V zener diode reference voltage on the positive input of U3A. The voltage divider, R23 and R24, between the 12 V dc supply and common ground provides the necessary feedback voltage to regulating amplifier U3A that regulates the supply voltage at +12 V dc. Darlington amplifier Q4 provides the necessary drive current to maintain the +12 V dc voltage.

Current limiting to approximately 100 mA on the +12 V dc supply is affected by R20 on the base and emitter of Q5. When excessive current is being drawn, Q5 turns on to limit the base drive of Q4, thus limiting the supply current.

### 5 Volt Supply

The regulated +5 V dc supply uses U3B for the regulating amplifier and a voltage divider between the +12 V dc supply and common ground to provide a +5 V dc voltage reference. Q7 decreases the load requirements of regulating amplifier U3B and provides a status voltage used by the restart circuitry. Q7 being an emitter-follower amplifier, the emitter voltage tracks the output of U3B. This voltage is applied to voltage follower amplifiers (Q1, Q2, and Q3) to provide the drive current necessary to maintain the required +5 V dc output voltage. Feedback voltage is impressed on the negative input of U3B to regulate the +5 V dc supply. Foldback current limiting results from resistor network R3, R4, and R5 providing bias to Q6. Foldback current limiting means that the maximum current available decreases as the output voltage decreases. Overvoltage protection is provided by VR1, R7, and Q12. If the +5 V dc supply voltage increases to about 6.8 V, the voltage drop across R7 becomes sufficient for Q12 to conduct and immediately lower the +5 V dc power supply voltage.

### Restart and Power Status

RST is the power status signal that initializes plotter activity. In case of electrical malfunction, it may halt the present plotter operation. Status of the +5 V dc power supply is ascertained via the collector of Q7. The bulk of the collector current from Q7 is transferred to VR2, a 4.3 V zener diode, which provides a logic 1 to U1C. Should the +5 V regulator depart from normal as a function of low input voltage, a 5 V overload, or a malfunction within the regulator loop, Q7 becomes reverse biased and applies a logic low to U1C.  $\overline{\text{RST}}$  then goes low, U2B provides a 15 ms delay pulse, keeping  $\overline{\text{RST}}$  low, as the +5 V dc supply is restored.

### Pen Solenoid

If PENDN2 is low, signifying a pen-up condition, no current passes through the pen solenoid. When PENDN2 goes high, the output of U1B goes low, turning on Q9 and Q11, connecting the negative pen solenoid line to -27 V dc. One-shot multivibrator U2B triggers on the leading edge of the PENDN2 signal, causing a 10 ms pulse that turns on Q8 and Q10 and connects the positive pen solenoid line to +27 V dc.

This 10 ms of additional voltage is to reduce the solenoid actuation time. The reduced voltage after solenoid actuation prevents large currents for long pen-down times. Other than the first 10 ms of a PENDN2 command, the positive pen solenoid line is clamped by a diode and resistor (CR3 and R38) in series with the common ground.

### Electrostatic Hold Down

The electrostatic hold-down voltage of approximately 880 V dc places electrostatic charges on the platen. The platen looks electrically like a capacitor in parallel with a bleeder resistor on which is produced electrostatic charges that have the ability to attract and hold paper. A class C blocking oscillator, Q10, is used to generate the electrostatic hold-down voltage. The CHART ON voltage is dependent upon the LOAD switch on the plotter control panel. CHART ON is either +12 V dc or open. When open, the voltage at the base of Q10 is insufficient to cause the transistor to conduct, thus cancelling the oscillations. When CHART ON is +12 V dc, Q10 becomes forward biased, which starts the oscillations. The transformer feedback coil on the base of Q10 maintains the oscillations by periodically triggering Q10 into conduction. Rectifier and filter circuits are on the high voltage secondary windings of T2.

There are two stages of transformer voltage isolation via T1001 and T2 to minimize shock hazards. Other precautions employed are the large series load resistors (R40 and R42) and the insulating property of the platen coating. If the platen coating is severely damaged, however, the platen must be replaced.



# Section 7

## CHARTS AND SCHEMATICS

This section contains the foldout diagrams and schematics, most of which pertain to the System Description Section of this manual. Diagrams included in this section appear in the following order:

### Checkout Diagram

This diagram is a full-size drawing for plotter checkout purposes. The results of the remote checkout program described in Section 1 are overlaid on this diagram to check for accurate plotter performance. Vectors are to be accurate to within the specifications mentioned in the Characteristics Section. The line width varies with the age of the pen and the amount of pen pressures exerted on the plotting surface.

### System Diagram

This is a block diagram of circuitry within the 4661 Digital X-Y Plotter. It illustrates the functional elements within the plotter along with communication lines between the elements. It is described in the System Description Section of this manual.

### Calculator Interface Diagram

The Calculator Interface Diagram shows the relationships between the circuit boards that control the Calculator Interface communication and data conversion. Description of the Calculator Interface is found in the System Description Section.

### Interface Timing

The Interface Timing foldout contains the timing signals used by the Calculator Interface circuits as they relate to the transfer of information between the calculator and the plotter. Also included is a timing diagram to show the signals used in converting BCD information from the calculator into binary information used by the plotter. The converter timing diagram also is used to illustrate how the information is transferred between circuits having separate

clocks and therefore different data rates. Interface circuits are described in detail in the System Description Section. Additional information can be found in the 21 and 31 Calculator Interfacing Information Manual.

### Plotter Timing

This foldout has the plotter timing diagrams for signals generated on the Timing card, and signals used by the Velocity Compensator card. This foldout is designed to be used as a reference when referring to the schematics in this section.

### Data Processing, Velocity Generation

The foldout contains a block diagram of the data manipulation circuitry, data memories and storage registers, velocity generation and compensation circuitry and velocity registers. This diagram is referred to extensively in the System Description Section of this manual.

### Initial Program







This foldout contains two figures. One is a program chart to be used as a guide to understand Initial Program operation. The second is a functional circuit diagram of circuitry that becomes activated when power to the plotter is turned on. Logic, other than that directly used, is eliminated to simplify the functional diagram and still keep it an accurate representation of circuit performance. This diagram is to be used as a troubleshooting aid. Initial Program description is found in the System Description Section of this manual.









### Plotter Program RUN Sequence

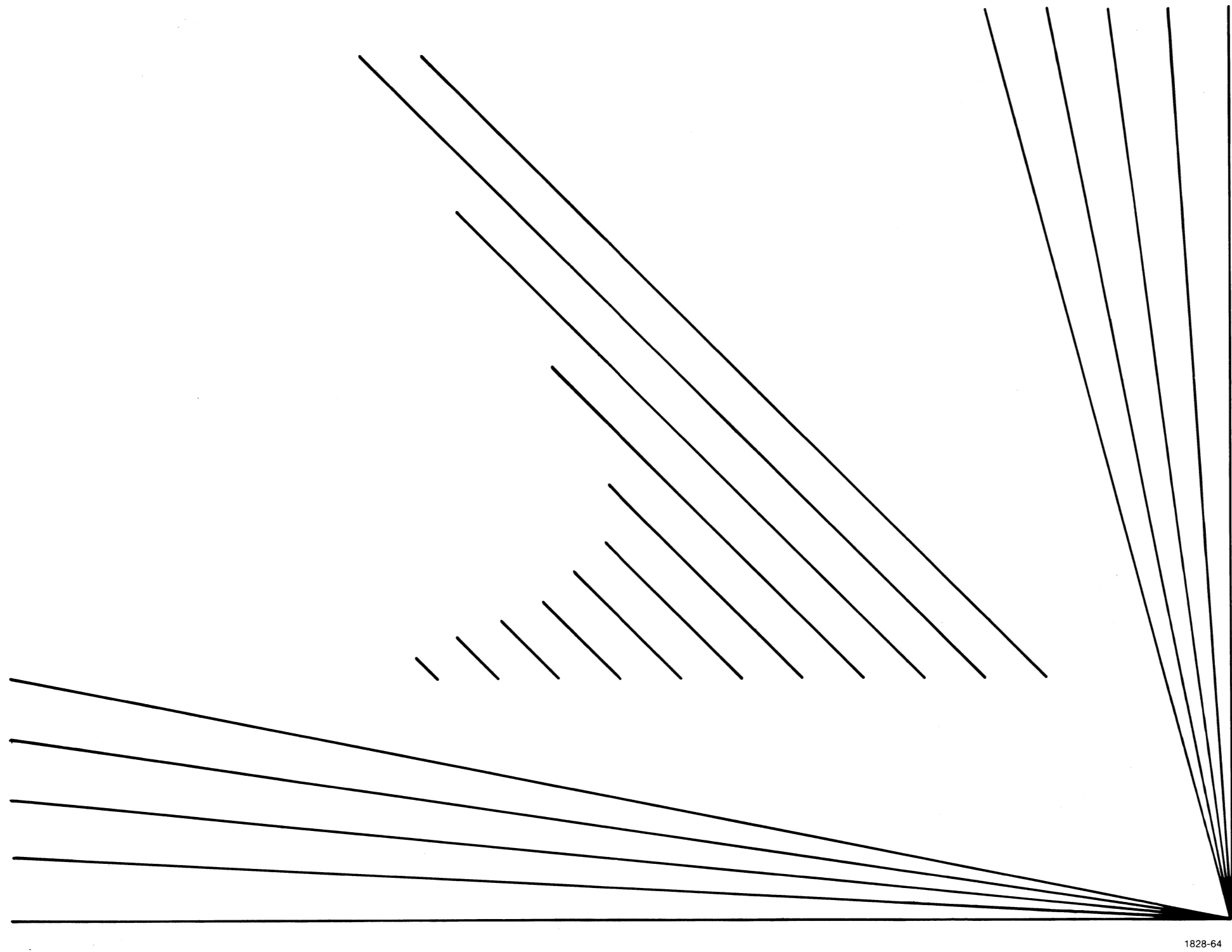
This foldout is a chart that describes the data processing functions performed by the plotter when it is given a command from the calculator to plot a vector. The RUN Sequence portion describes data processing activity that is controlled by circuitry on the Axis Control card during any axis movement. The RUN Sequence is described both in the Plotter Program writeup and the Axis Control writeup in the System Description Section of this manual.

## Charts and Schematics—4661 Service

The schematics are in order by assembly number as they are referenced in the parts lists. This is the same order as the jack number sequence on the Mother Board. Included with the schematics are parts and component locator tables. The schematic order is as follows:

Power Regulator   
Step Drive    
Velocity Com.   
Velocity Gen.   
Panel Interface 

Timing card   
Program card   
Offscale card   
Data card   
Access Control   
Data Converter   
Cal. Interface #2   
Cal. Interface #1 



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Fig. 7-1. Checkout Diagram

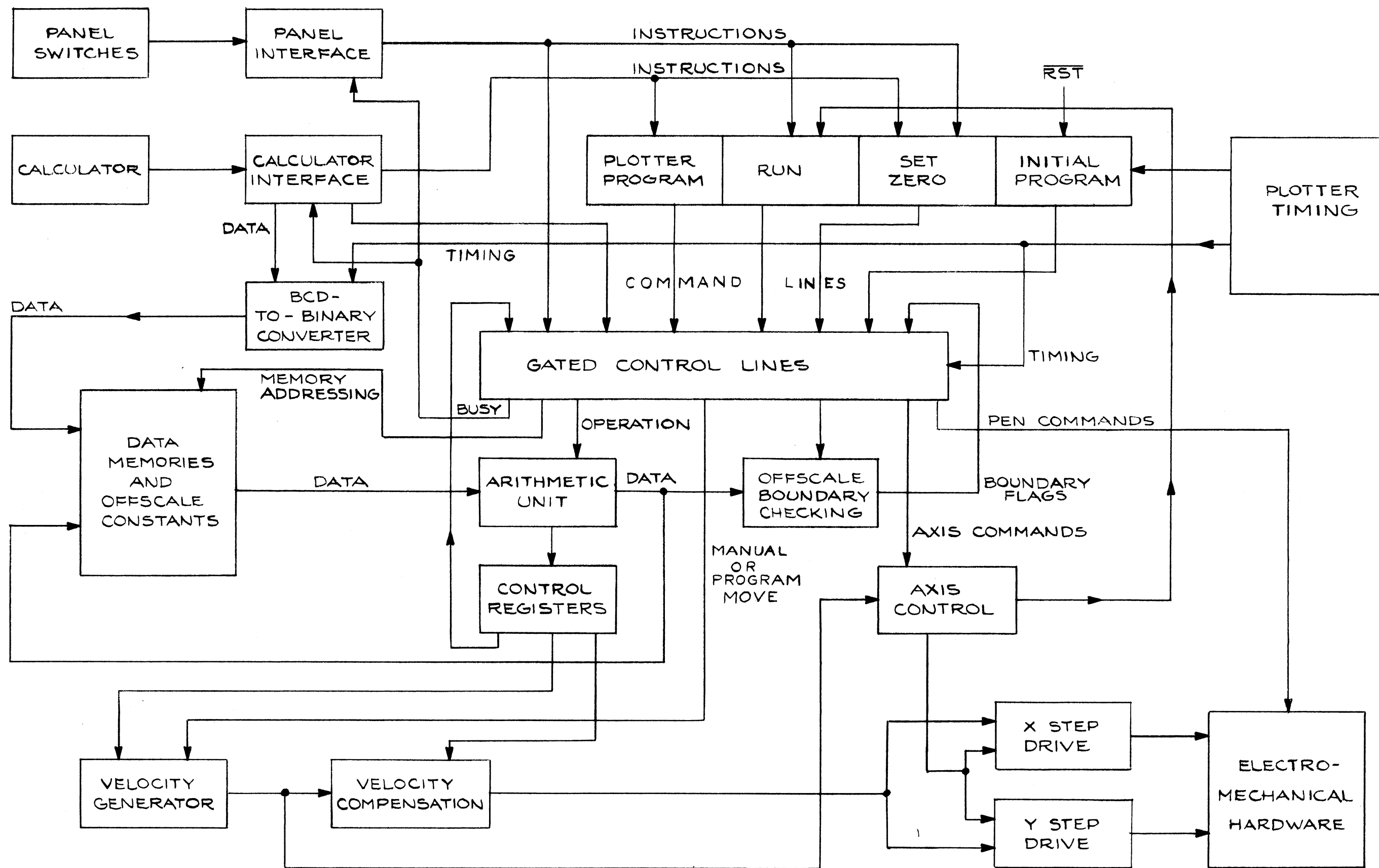


FIG. 7-2 PLOTTER SYSTEM BLOCK DIAGRAM

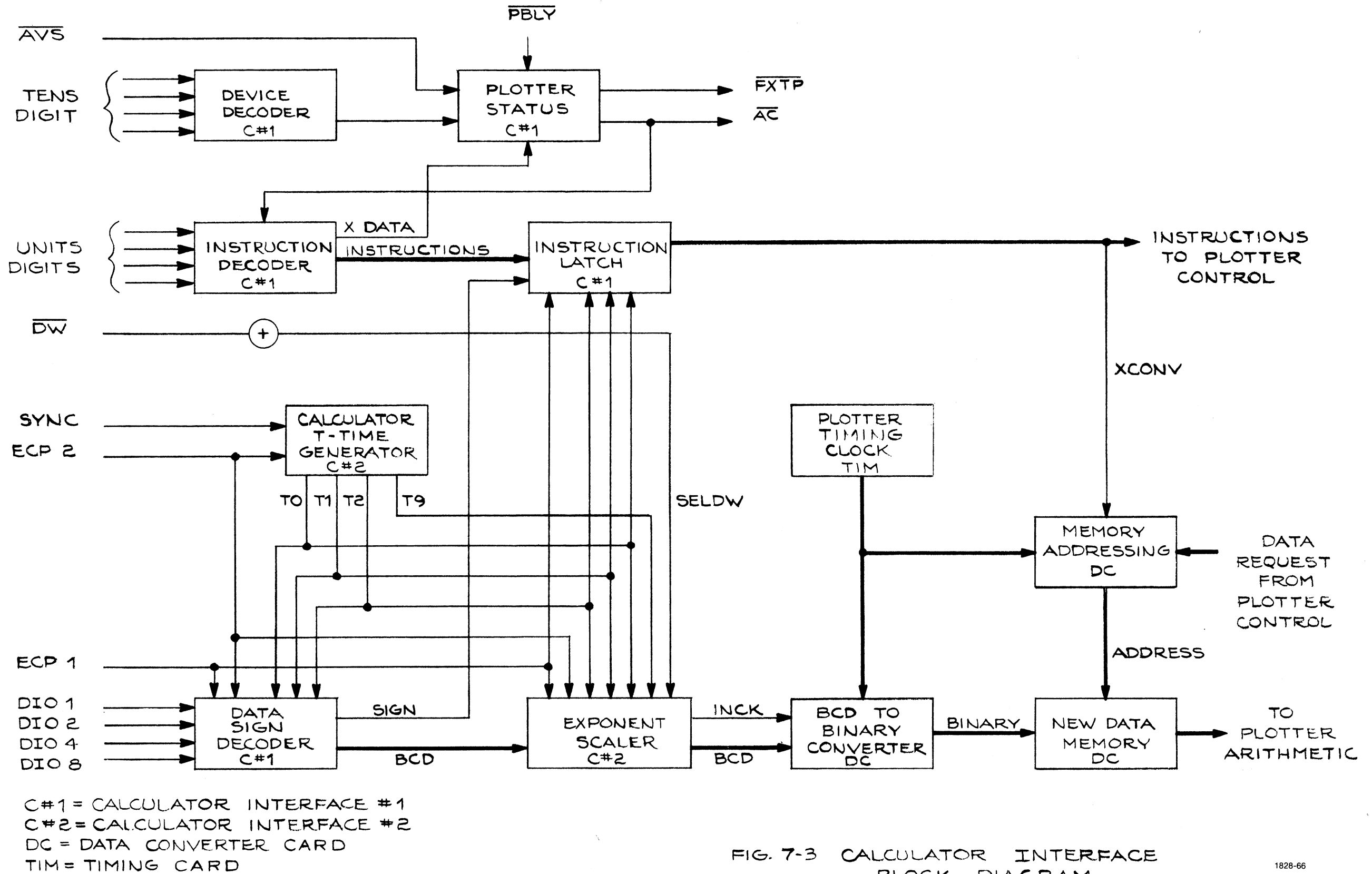


FIG. 7-3 CALCULATOR INTERFACE BLOCK DIAGRAM

1828-66

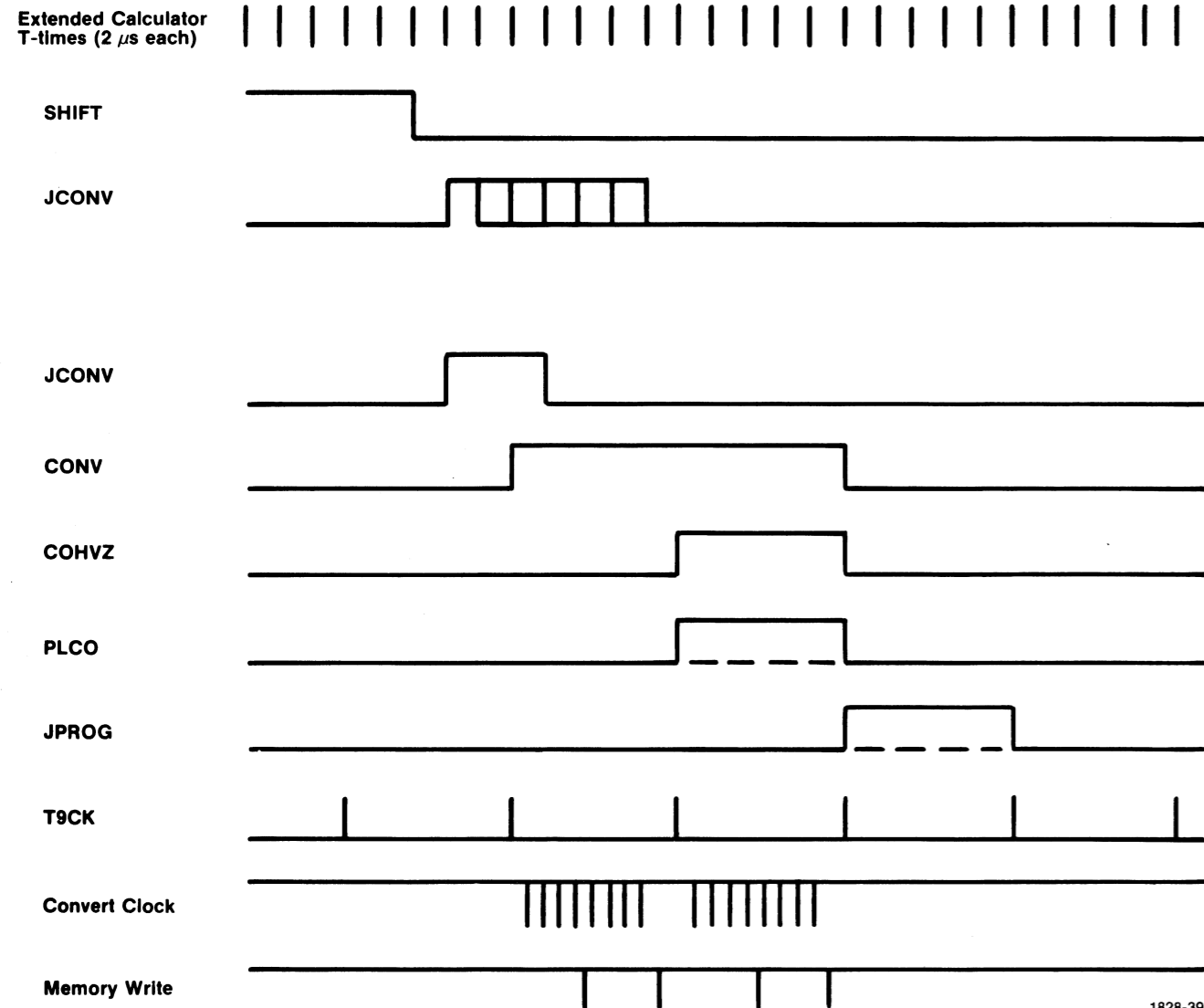


Fig. 7-4. Converter Timing.

1828-39

INTERFACE TIMING

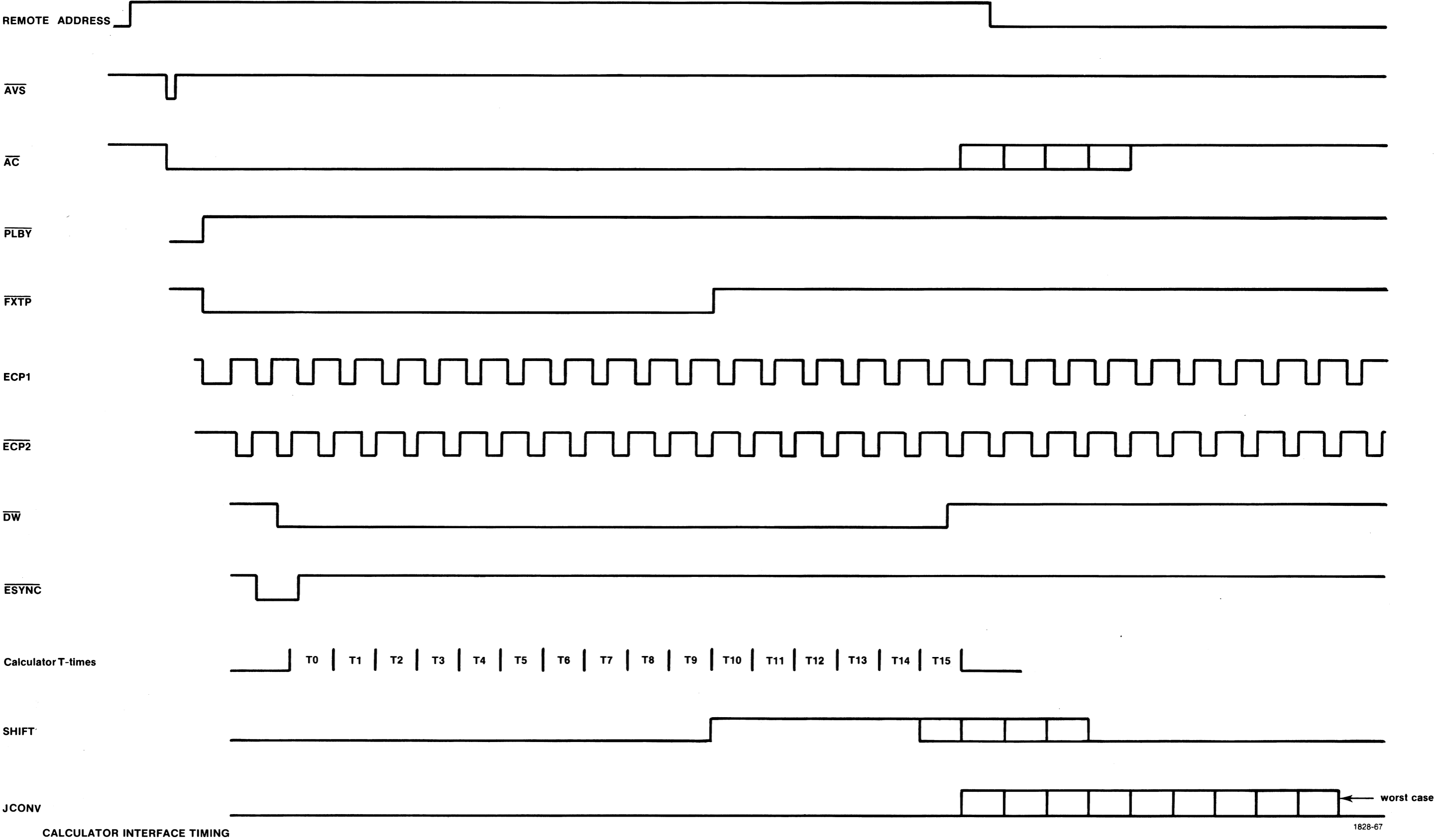
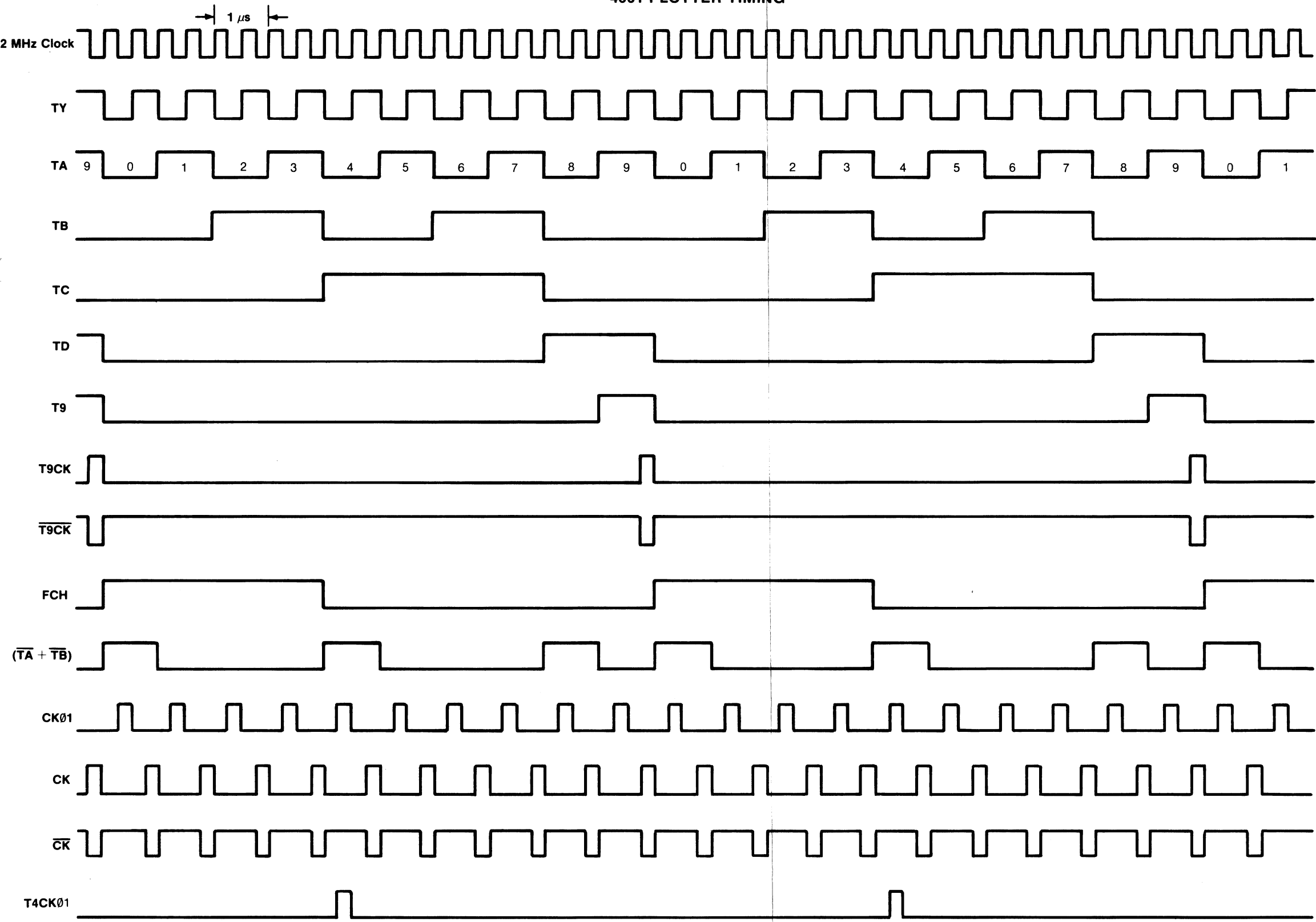


Fig. 7-5. Interface Timing

4661 PLOTTER TIMING



1828-68

Fig. 7-6. Plotter Timing

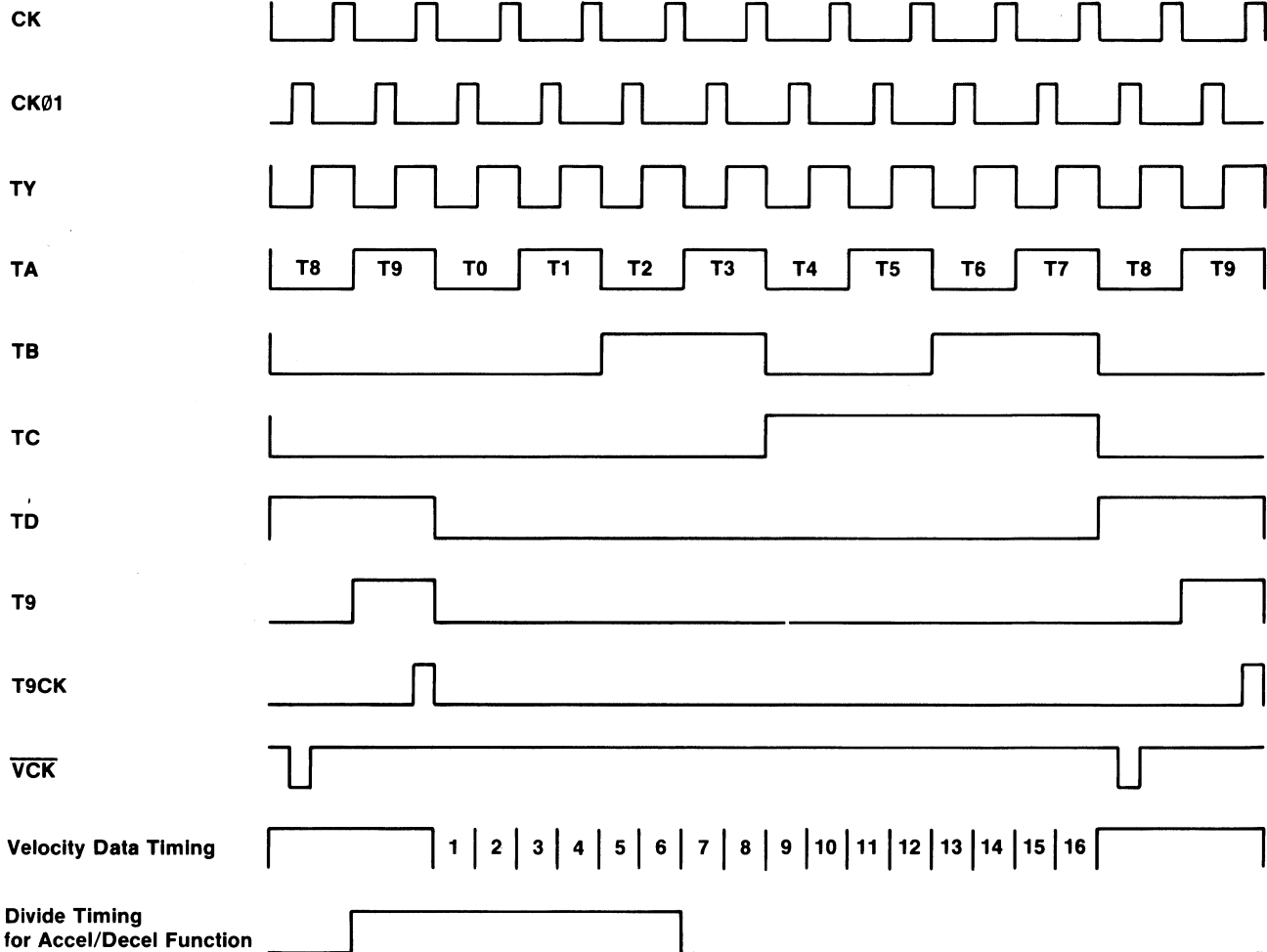


Fig. 7-7. Velocity Gen. Timing

1828-47

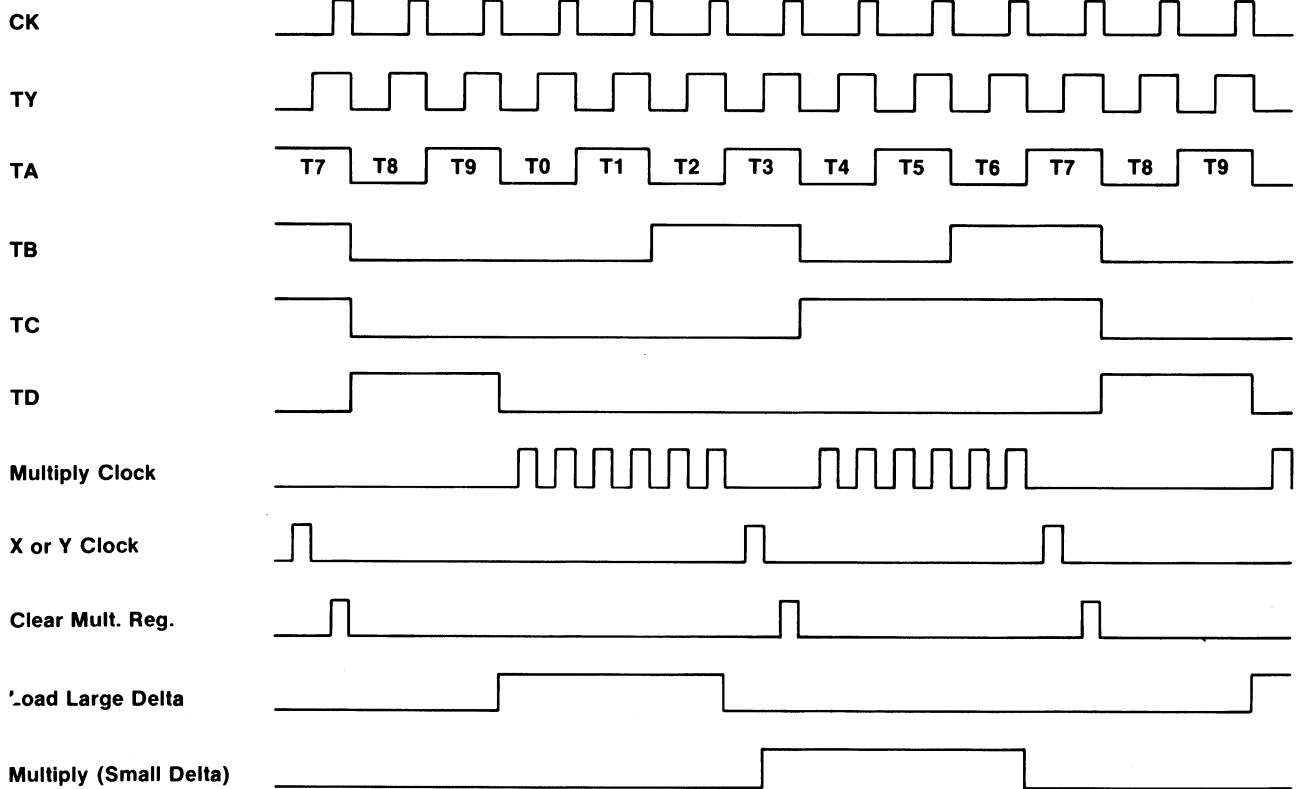
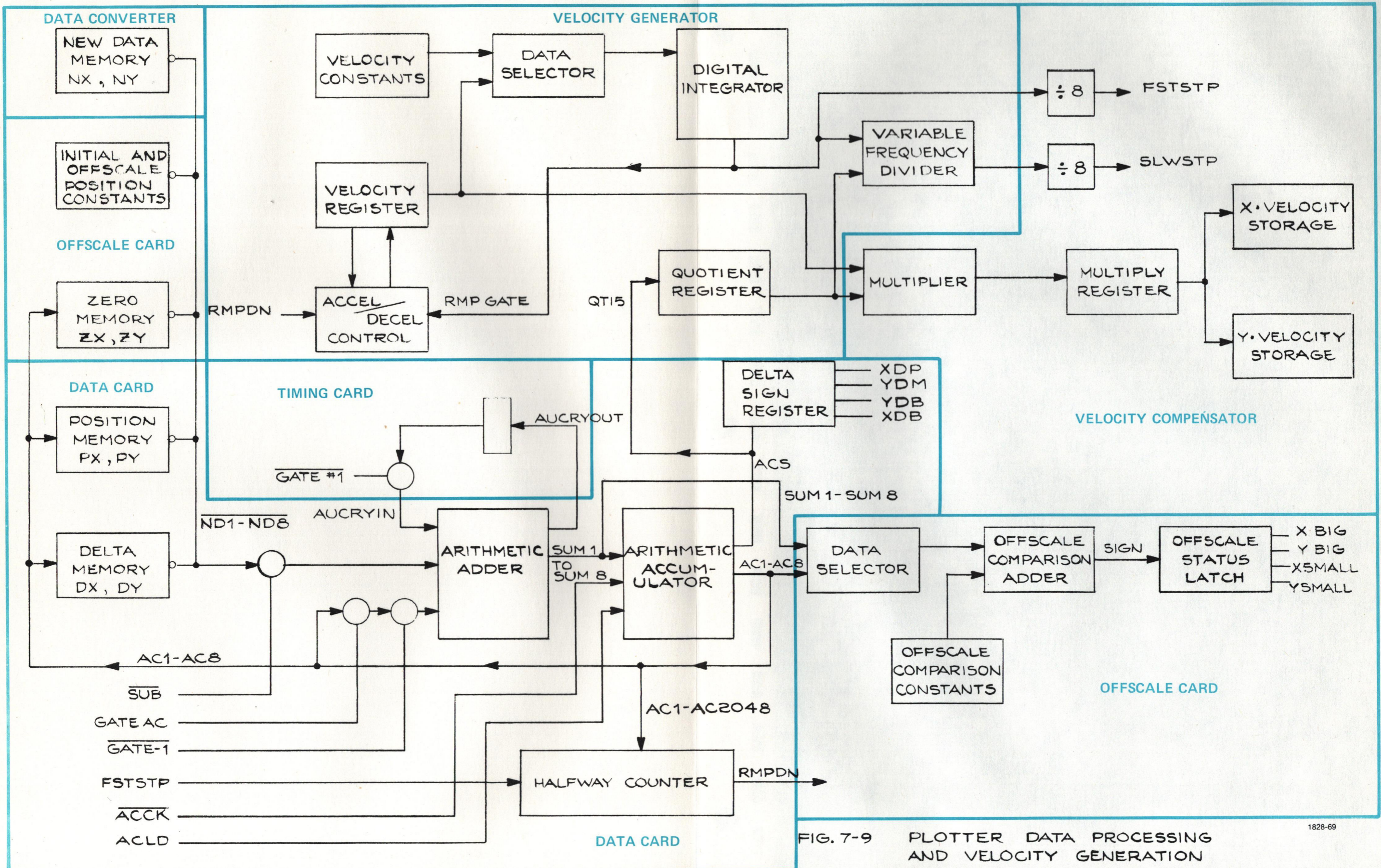


Fig. 7-8. Velocity Comp. Timing

1828-52

FIG. 7-9 PLOTTER DATA PROCESSING  
AND VELOCITY GENERATION

## 4661 INITIAL PROGRAM

MAJOR FUNCTION	Initial X Zero Load "32" into ZX		Initial Y Zero Load "32" into ZY		X Initial Move (right) until XLIM is asserted		Initial X Position Load "3272" into PX		Y Initial Move (down) until YLIM is asserted		Initial Y Position Load "0" into PY	
COMMAND LINE	ISTZROX		ISTZROY		XINITMV		ISTABSX		YINITMV		ISTABSY	
FETCH	(32)		(32)		1 or more cycles		(3072)		1 or more cycles		(0)	
LOAD	Const		Const				Const				Const	
WRITE	AC	ZX	AC	ZY			AC	PX			AC	PY
FCH WRT												

AC = Arithmetic Accumulator  
 ZX, ZY = Registers of Zero Memory  
 PX, PY = Registers of Position Memory  
 FCH = Plotter T-times T0, T1, T2, T3  
 WRT = Plotter T-times T4, T5, T6, T7

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Fig. 7-10. Initial Program Chart



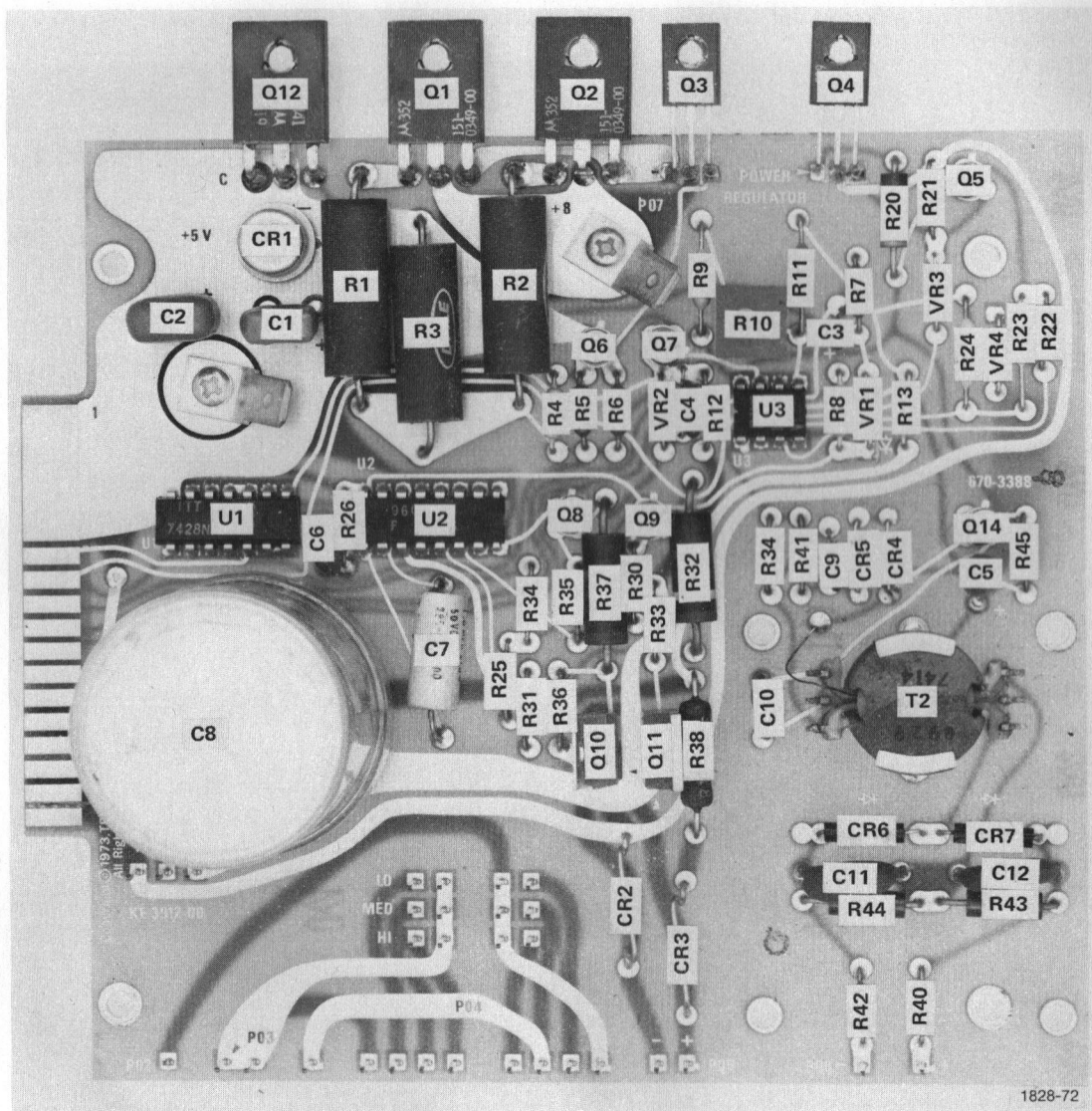
CYCLE NAME	P00		P01		P02		P03		P04		P05		P06		P07		P08		P09		P10		P11		P12		P13		P14		P15-P29		EARLY PEN		
MAJOR FUNCTION	FETCH NEW X DATA		CALCULATE REQUESTED PX AND TEST LIMITS		FETCH NEXT PX		CALCULATE DX AND STORE SIGN		FETCH NEW Y DATA		CALCULATE REQUESTED PY AND TEST LIMITS		FETCH NEXT PY		CALCULATE DY AND STORE SIGN		CALCULATE  DX		CALCULATE  DY		FETCH  DX		CALCULATE  DX  -  DY  STORE SIGN		FETCH THE BIGGER -DELTA/ LOAD HALFWAY COUNTER		FETCH THE SMALLER  DELTA		DIVIDE OPERATION (Requires SMALL Δ / BIG Δ)		16 10/μs Cycles) P29 ENABLES OFFSCALE PEN CONTROL		IF LEAVING PLOTTING BOUNDARY WAIT 35 ms OTHERWISE WAIT 10 μs		
	T0 - T4 FCH	T4-T7 WAT																																	
Accumulator Data	0		AC		0		AC		0		AC		0		AC		0		0		0		0		AC		0		0		AC		AC		0
Arithmetic Opr'n	±		X2	+	+		-		±		X2	+	+		-		±		±		+		-		-		+		±		X2	±		X2	+
Memory Fetch	NX		PX/ZX		DX		PX		NY		PY/ZY		DY		PY		DX		DY		DX		DY		DY / DX		DY / DX		DY / DX		DY / DX		DX		
Offscale Data					3072 / 0								2048 / 0																						
Memory Write				DX				DX				DY			DY		DX		DY																
Operation Qualifier	XM		XFS						YM		YFS						YDM		YDB											QT15		QT15			
Memory Qualifier			XA								YA														YDB		XDB		YDB		YDB				
	Subtract if XM = 1		Enable (for full scale) Extra Shift (ACX2)	Address ZX if XA = 1 Check Zero Limit	Check Maximum Limit	Latch Offscale Data	"3072" Big Offscale Value "0" = Small Offscale Value		Store Sign		Subtract if YM = 1	(for full scale) Enable Extra Shift (ACX2)	Address ZY if YA = 1 Check Zero Limit	Check Maximum Limit	Latch Offscale Data	"2048" = Big Offscale Value "0" = Small Offscale Value		Store Sign		Subtract if YDM = 1		Subtract if YDB = 1			Address DY if YDB = 1	Set Hi in LSB, Quotient Reg. (QT15)	Load Halfway Counter	Address DY if XDB = 1	Update Offscale Pen Controls	Address DY if YDB = 1 Subtract if QT15 = 1	Shift Sign to Quotient (LSB)	Multiply AC by 2	Address DY if YDB = 1 Subtract if QT15 = 1	Shift Sign to Quotient (LSB)	Multiply AC by 2

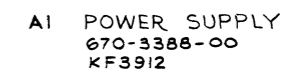
DIVIDE

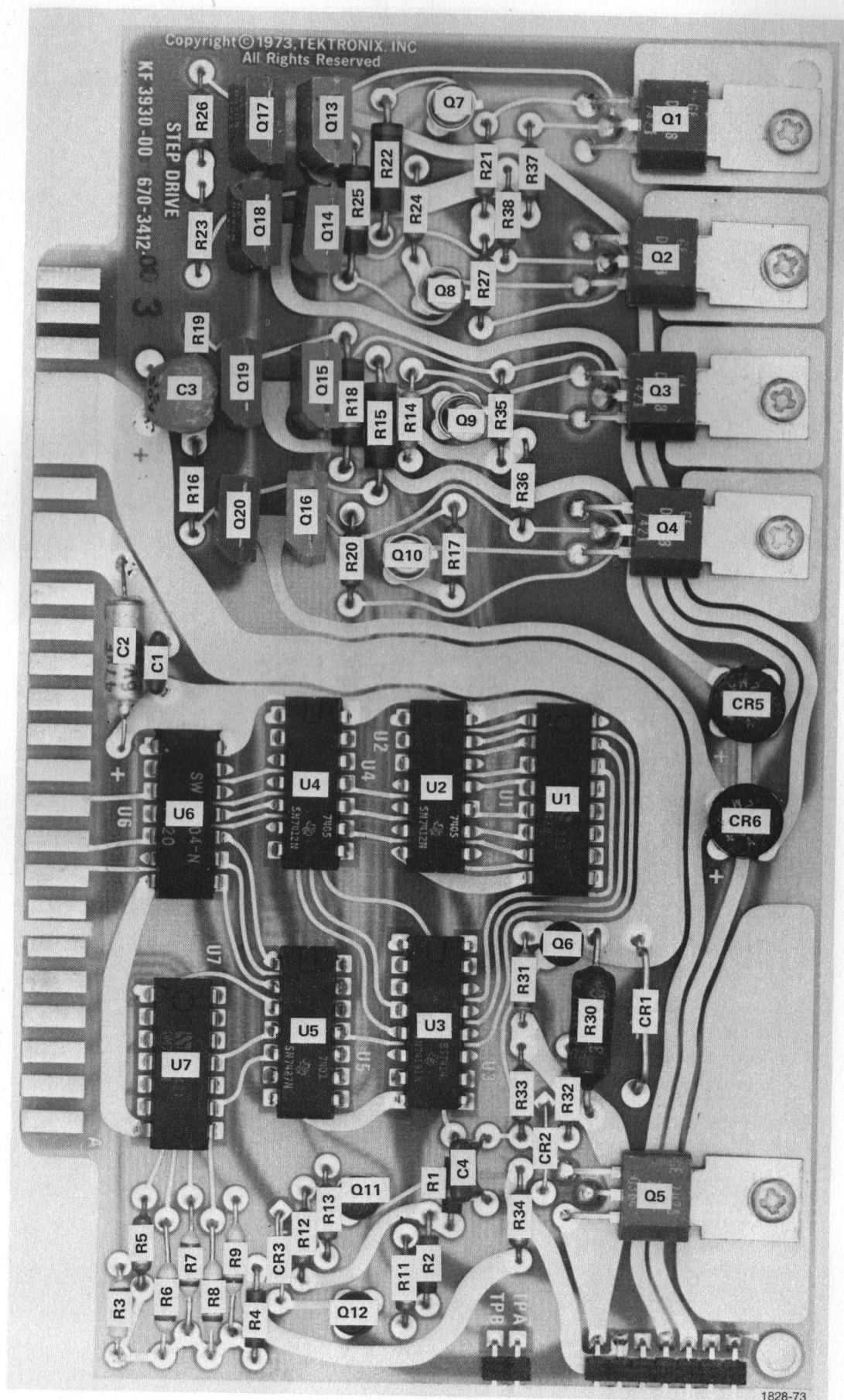
Fig. 7-12. Plotter Program Run Sequence.



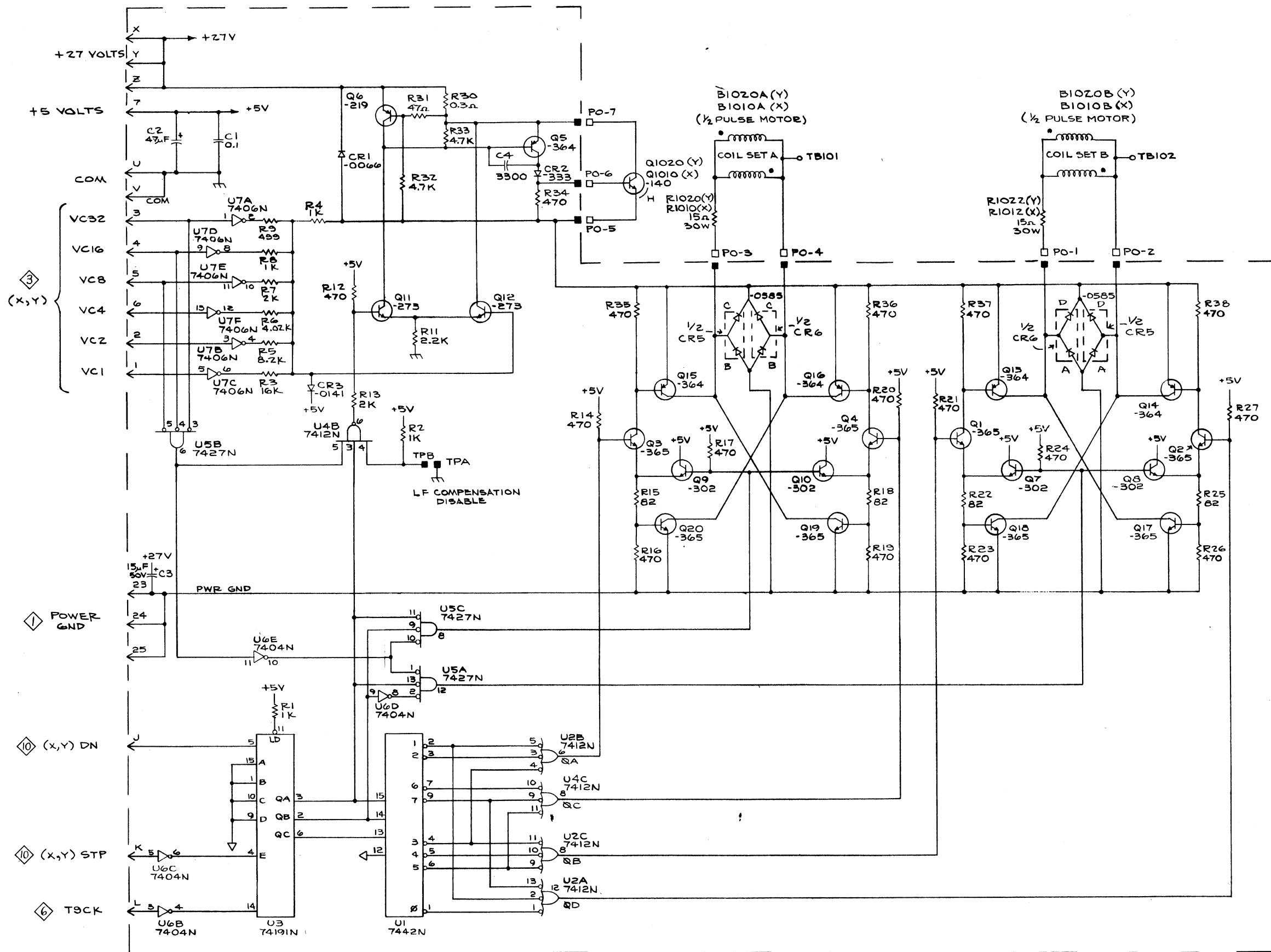
**Fig. 7-12. Plotter Program Run Sequence.**







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ⓐ

A2 & A14

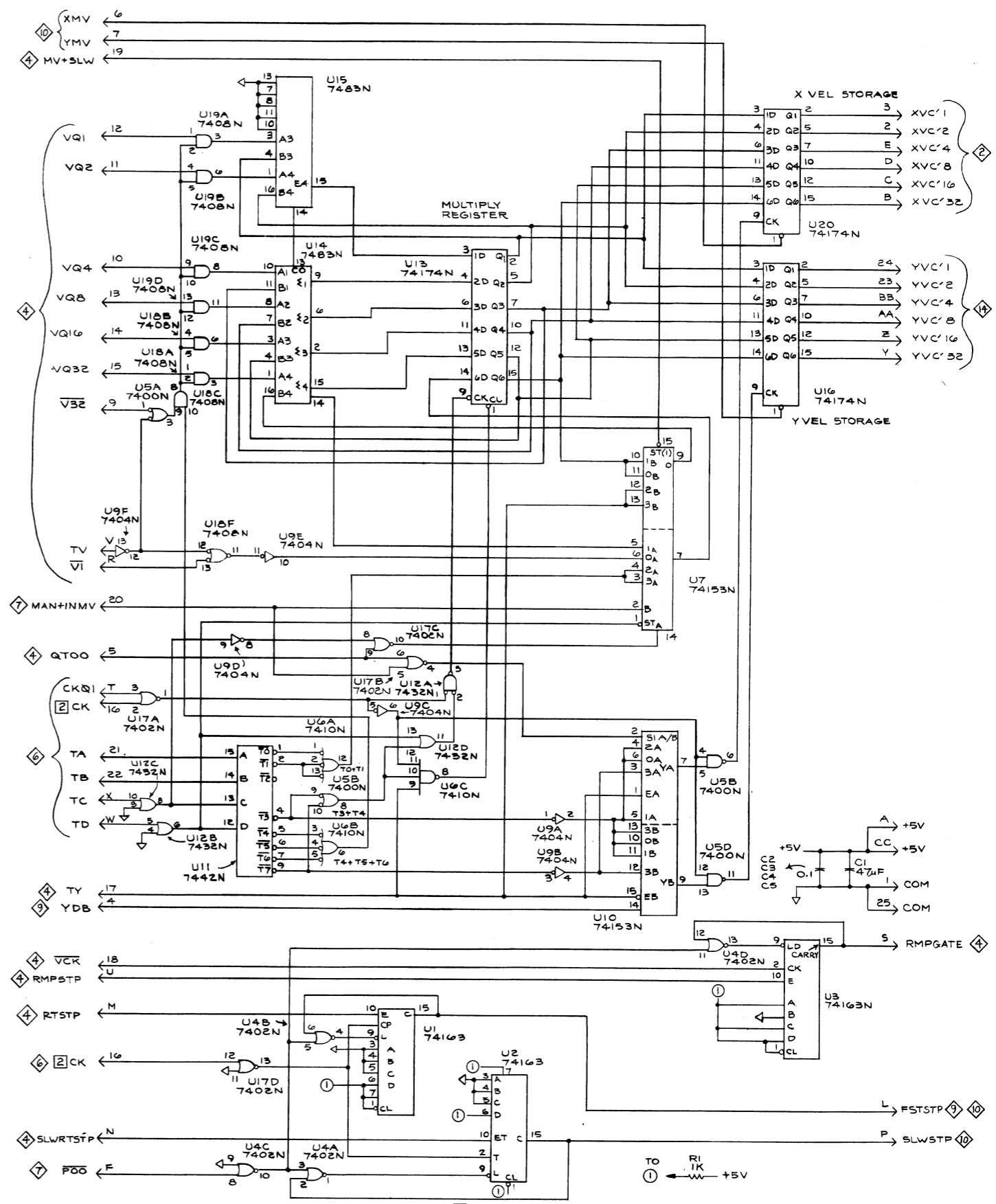
X & Y STEP DRIVE ② ④  
670-3412 KF3930

STEP DRIVE

②

④





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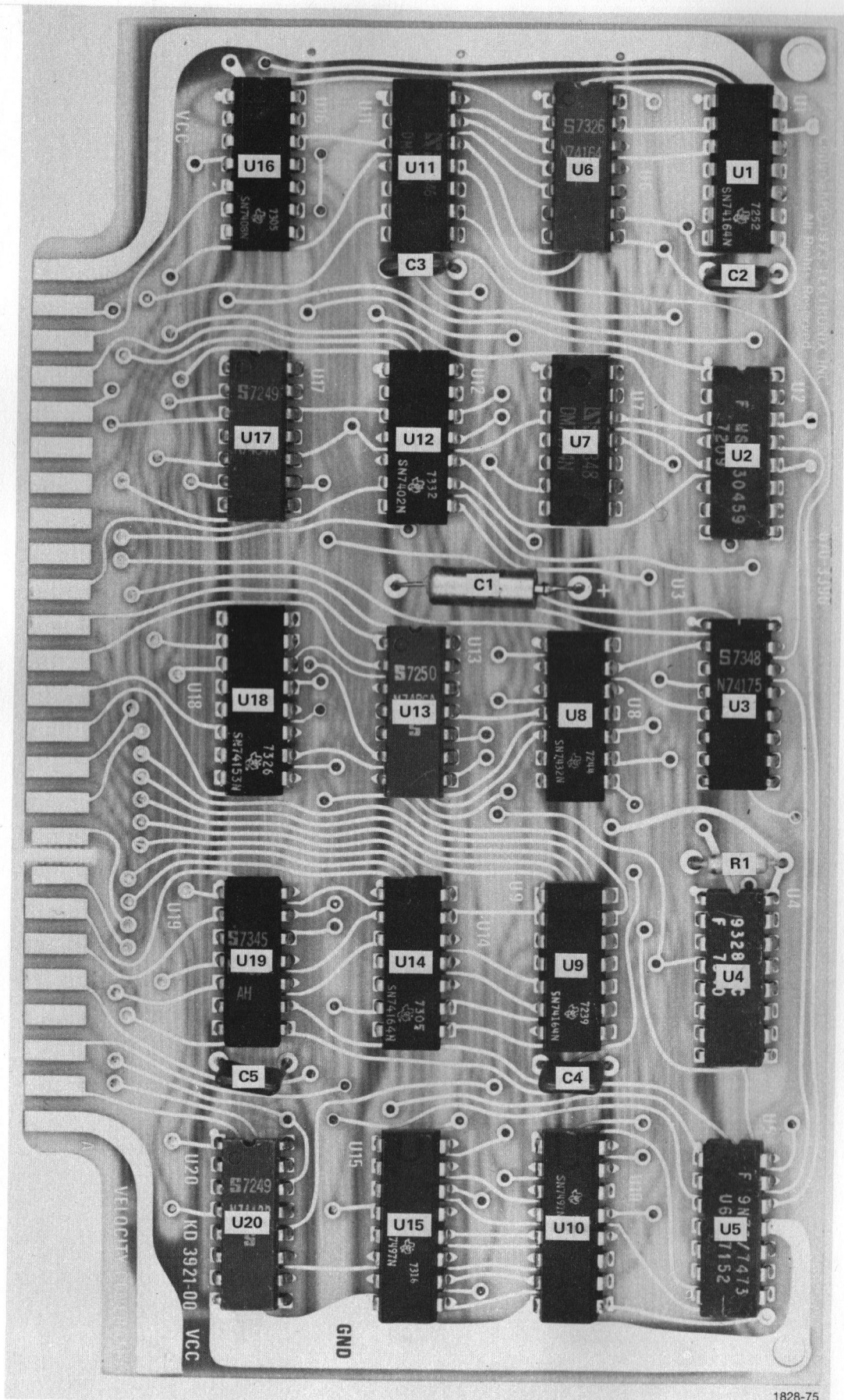
ⓐ

② APPEARS TWO TIMES

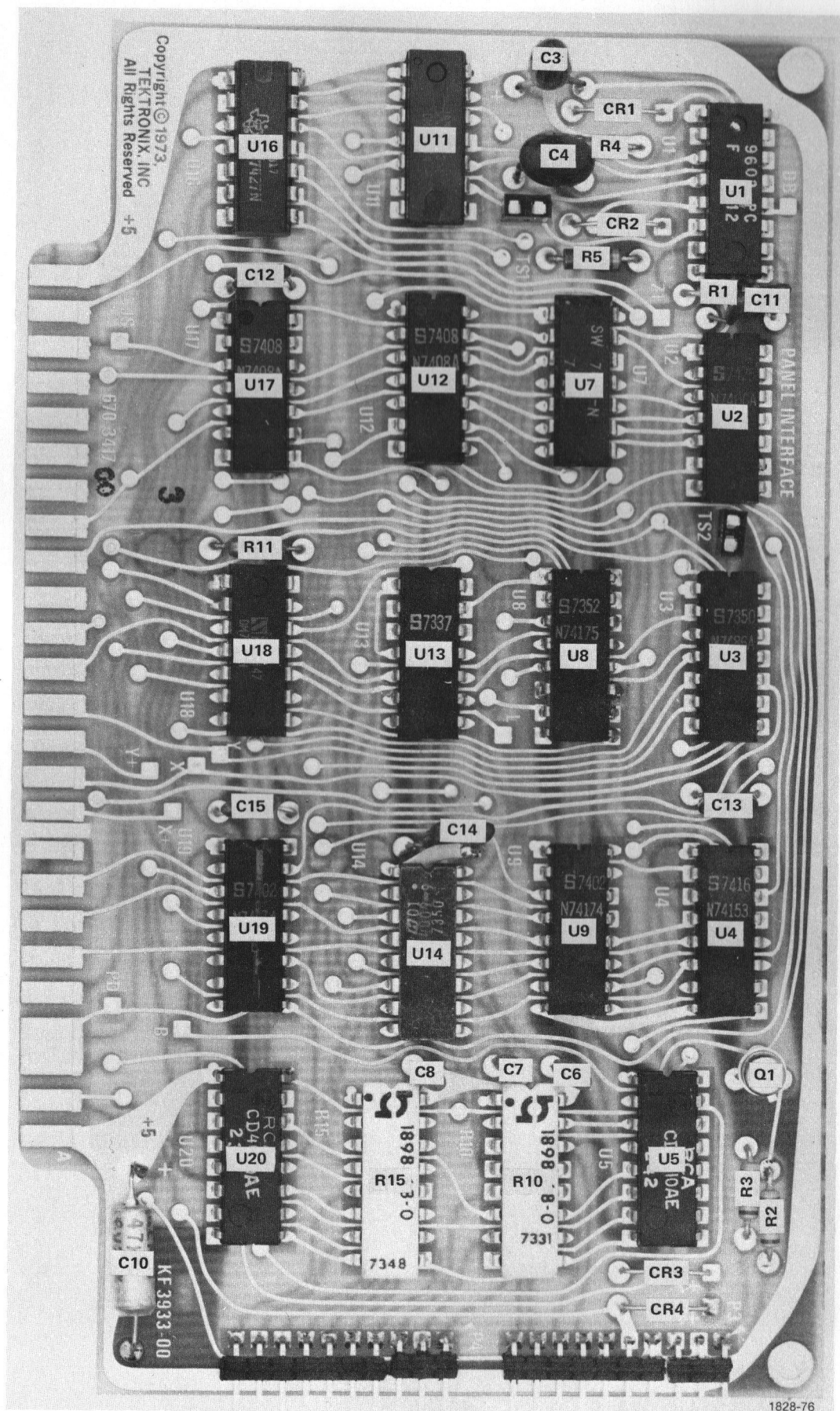
670-3395-00 KC3920  
A3 VELOCITY COMPENSATOR

VELOCITY COMP.

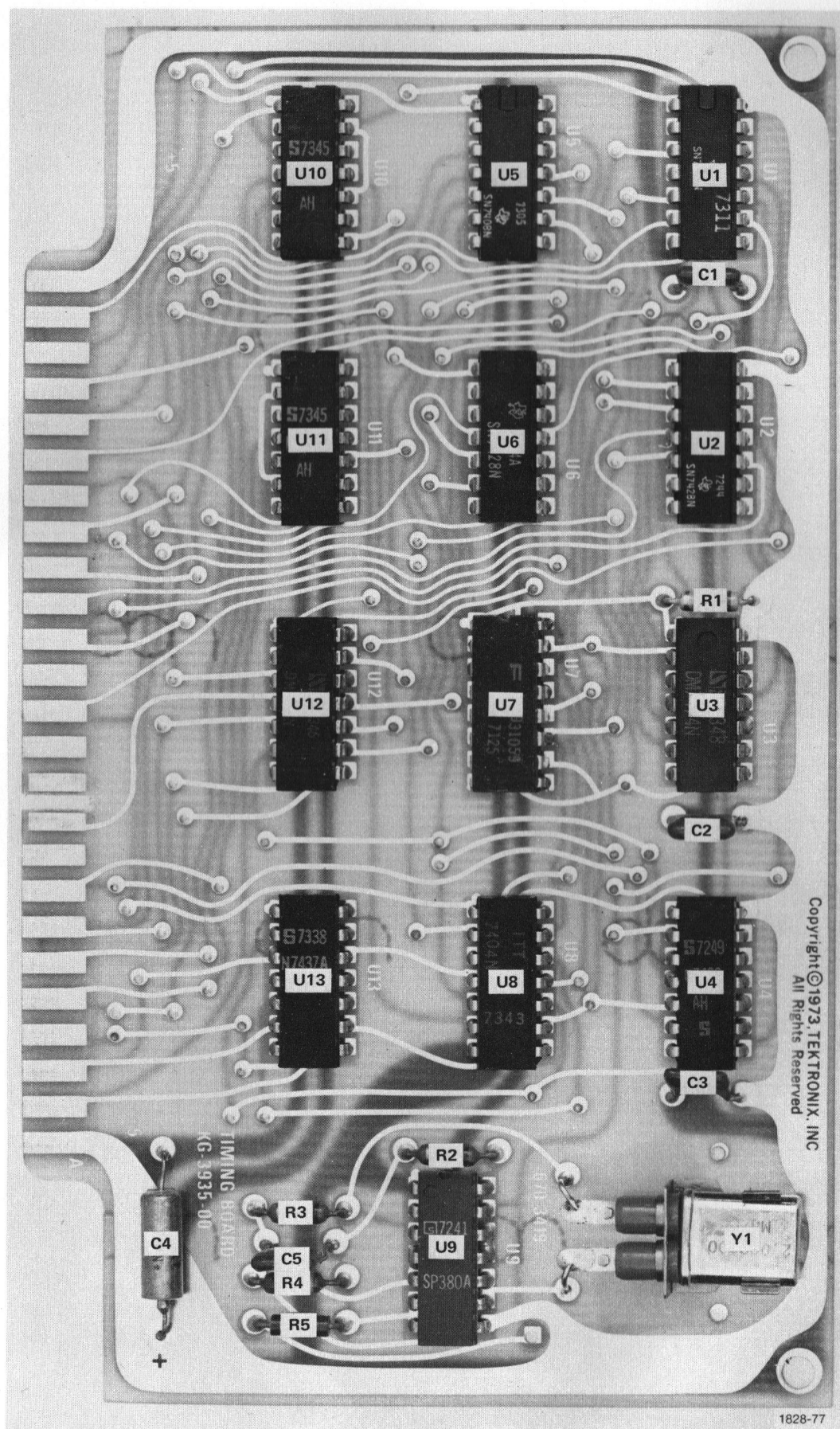
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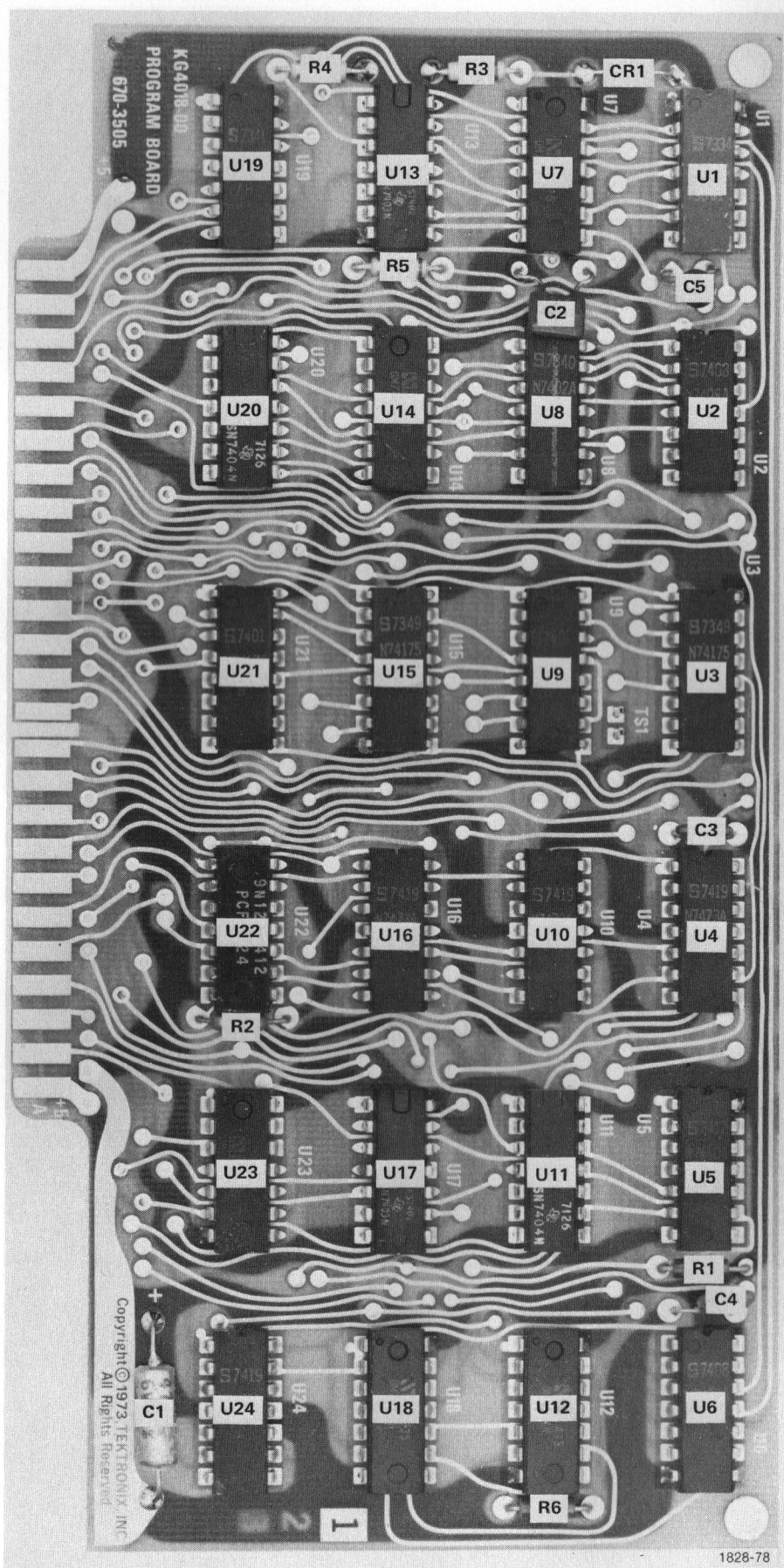




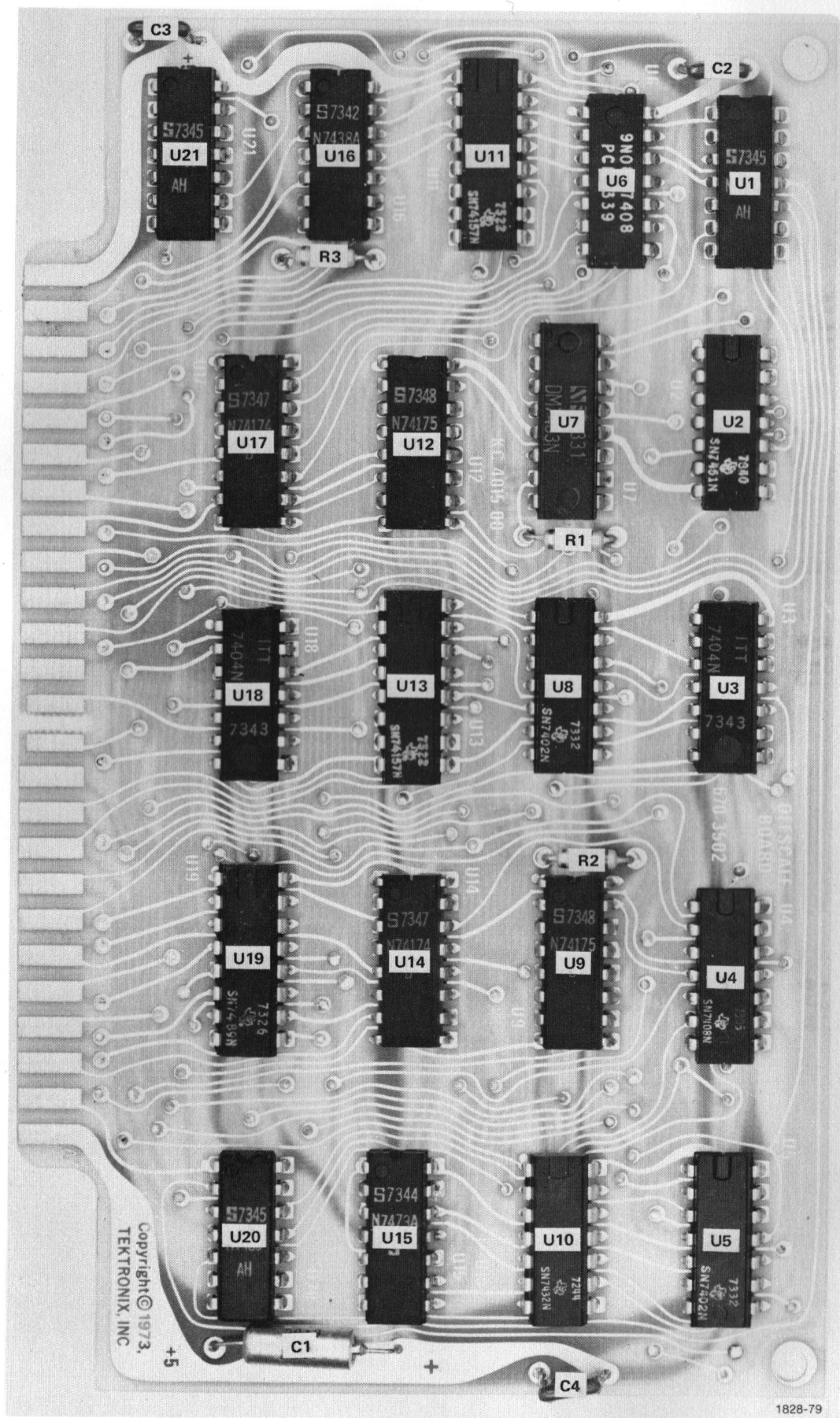


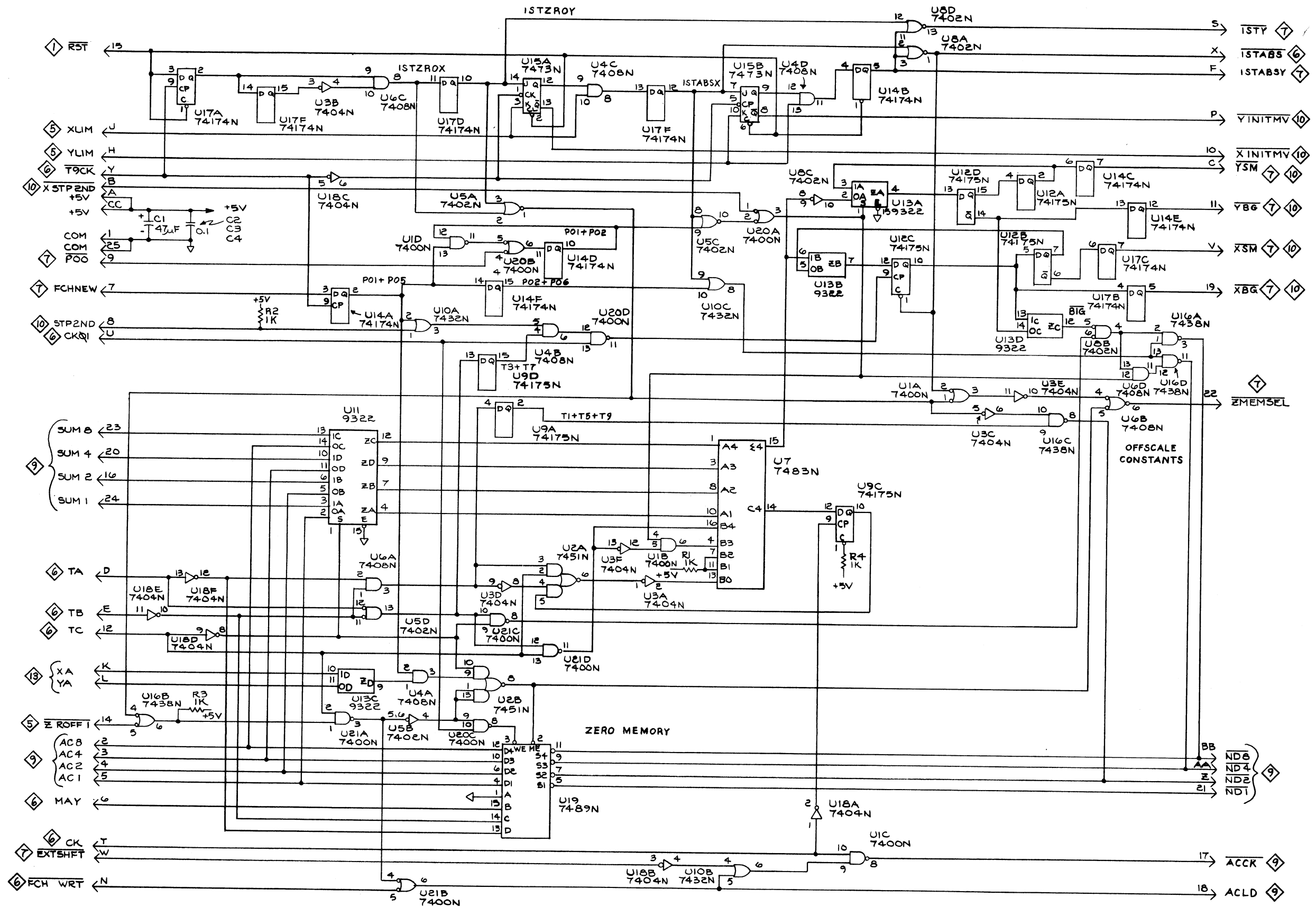












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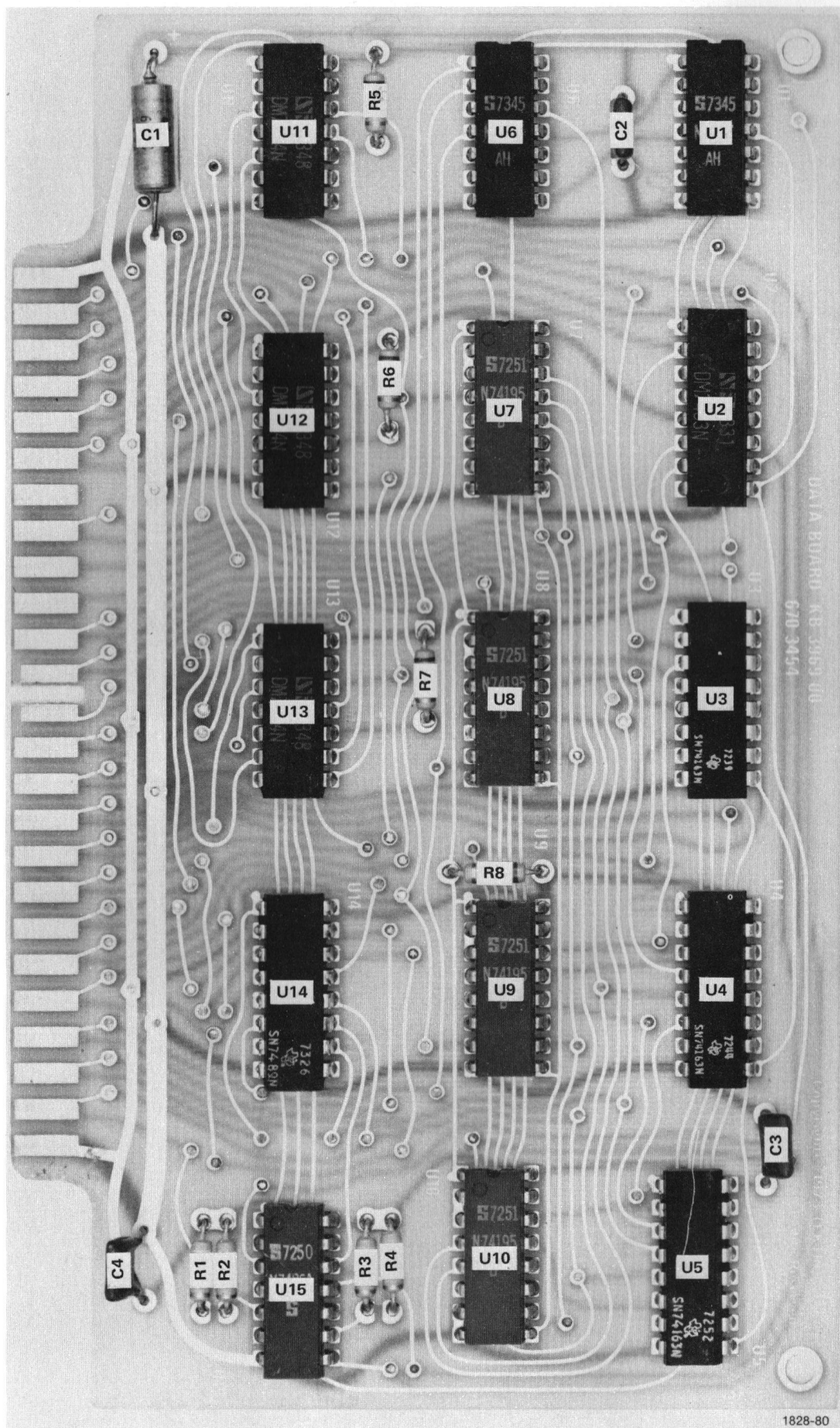
A8

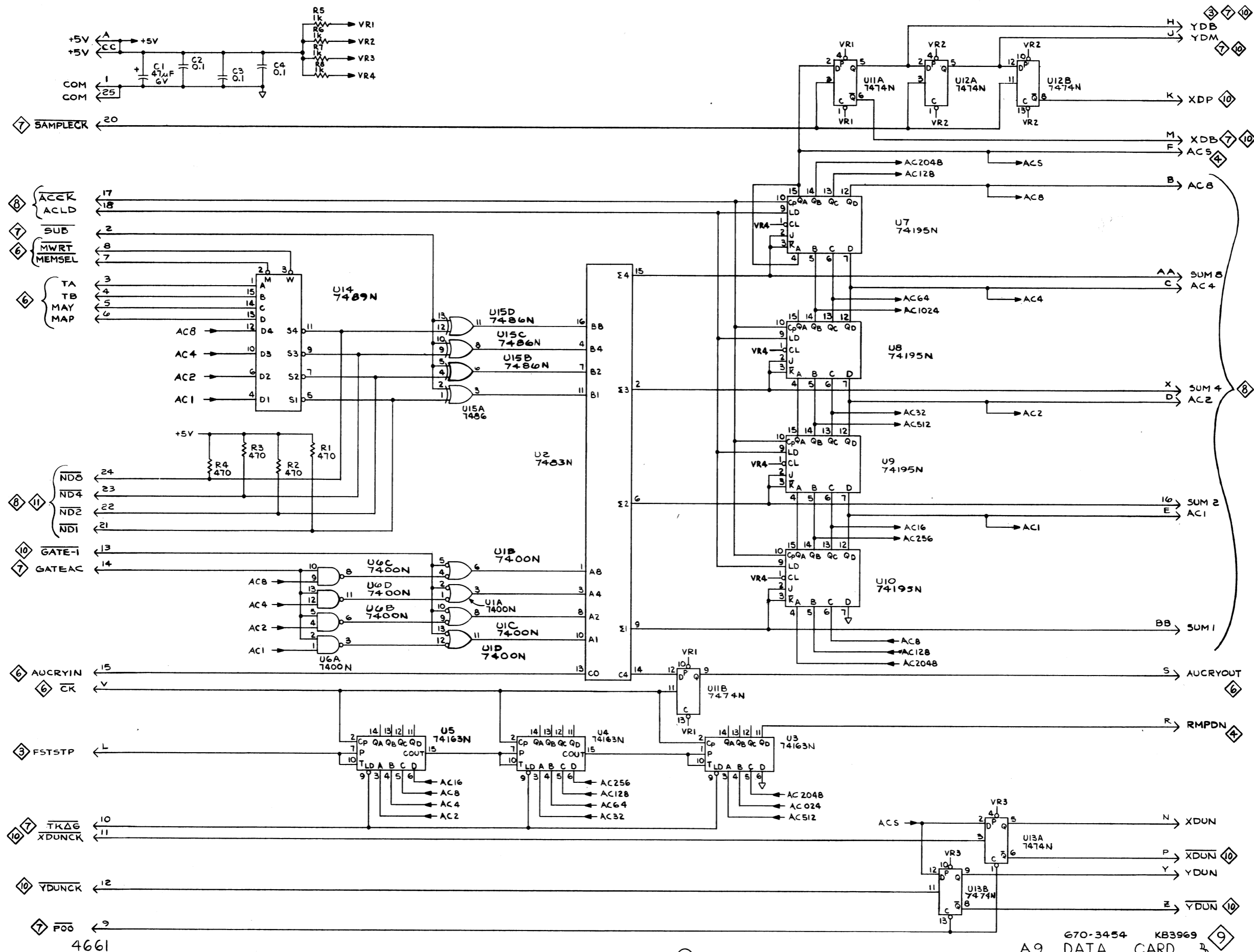
OFFSCALE CARD

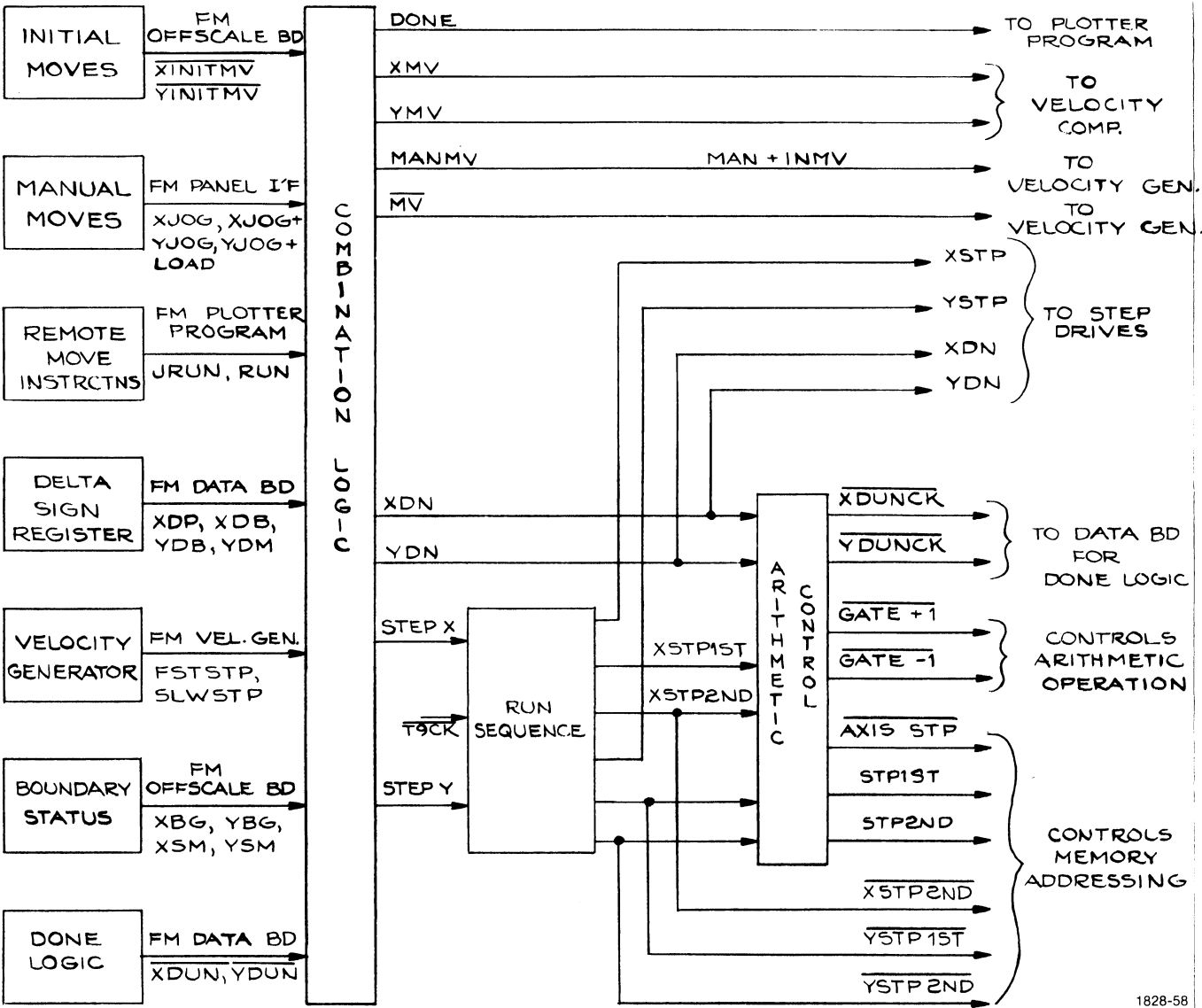
670-3502  
KC4015

OFFSCALE CARD

8

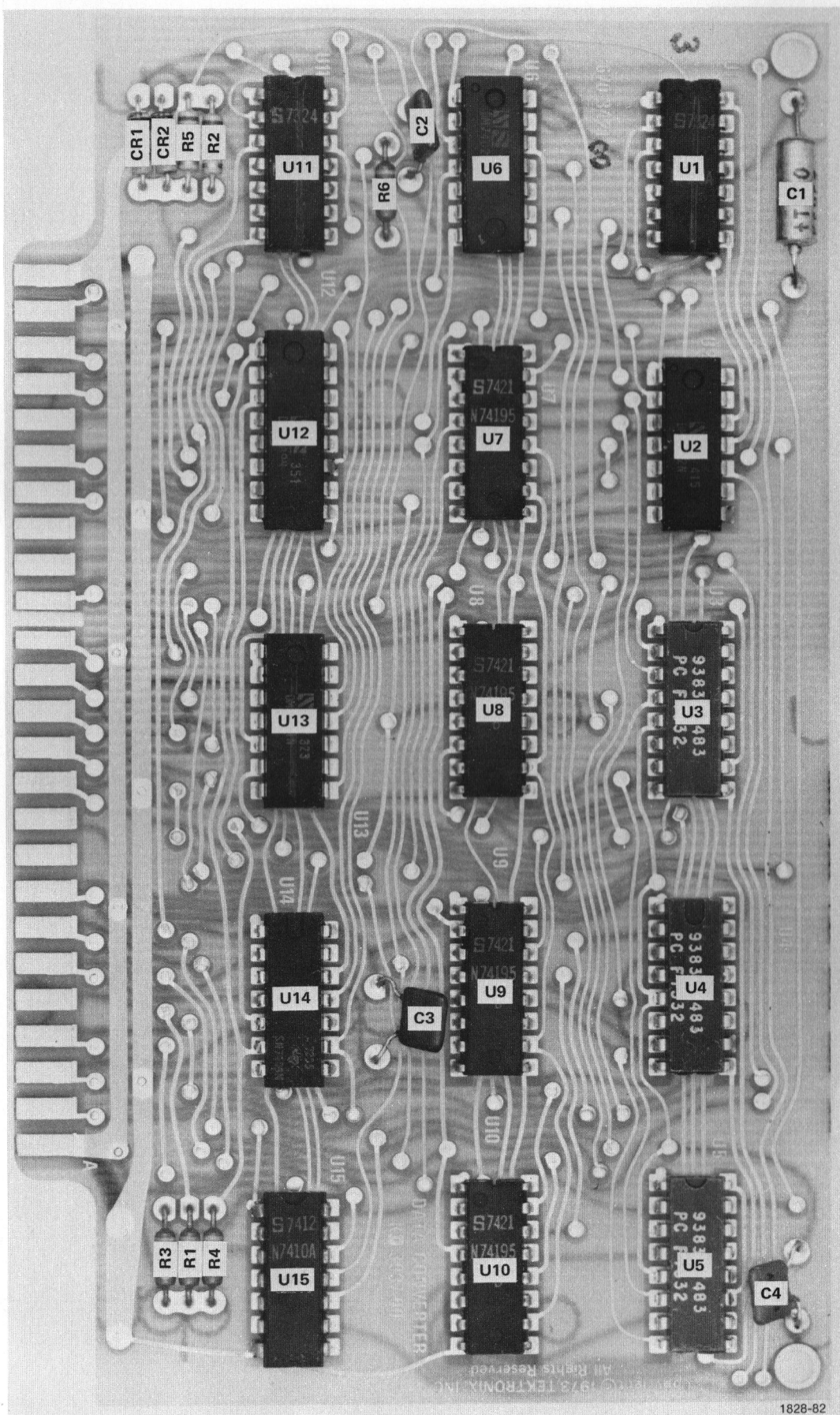






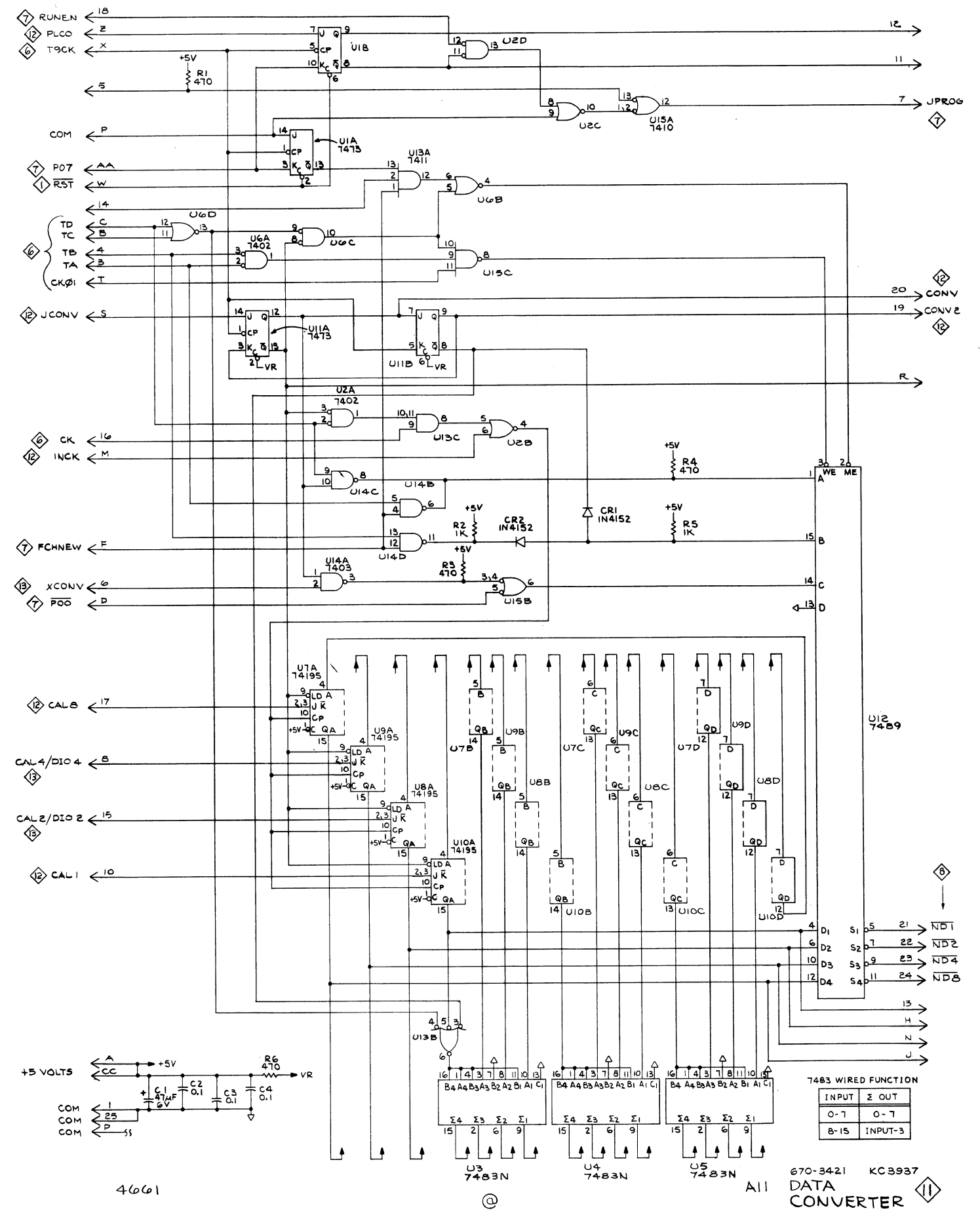




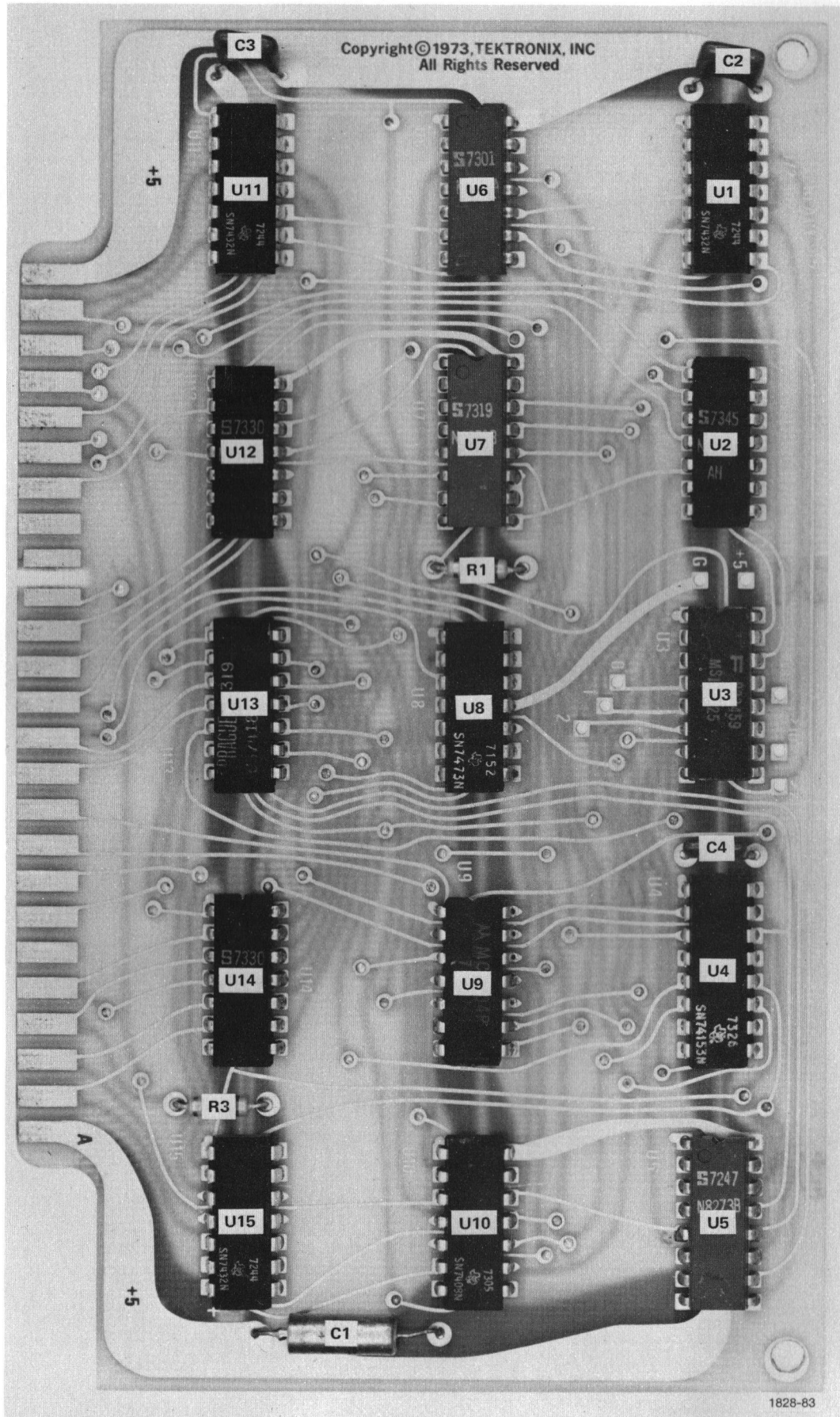


DATA CONVERTER

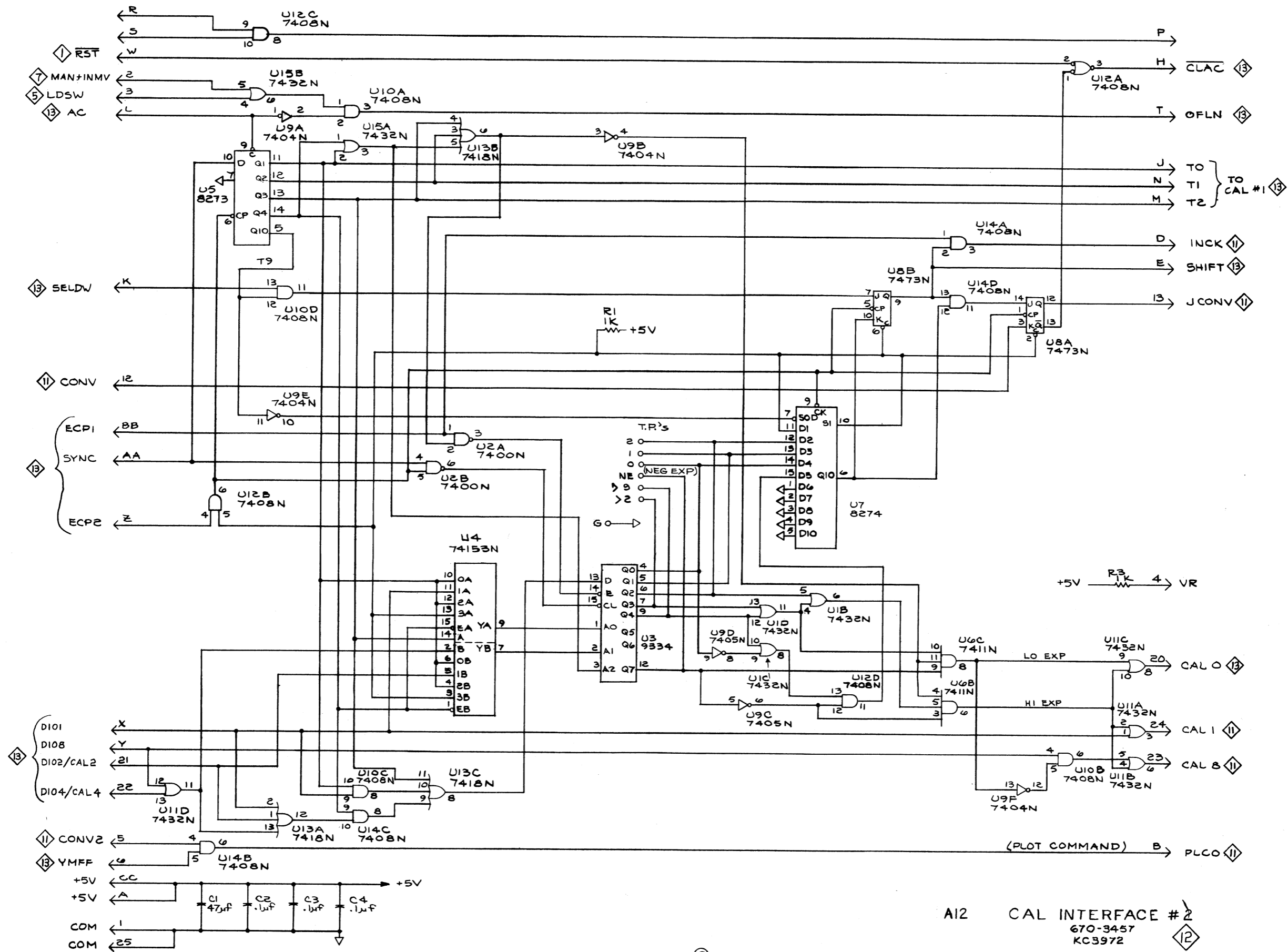
11



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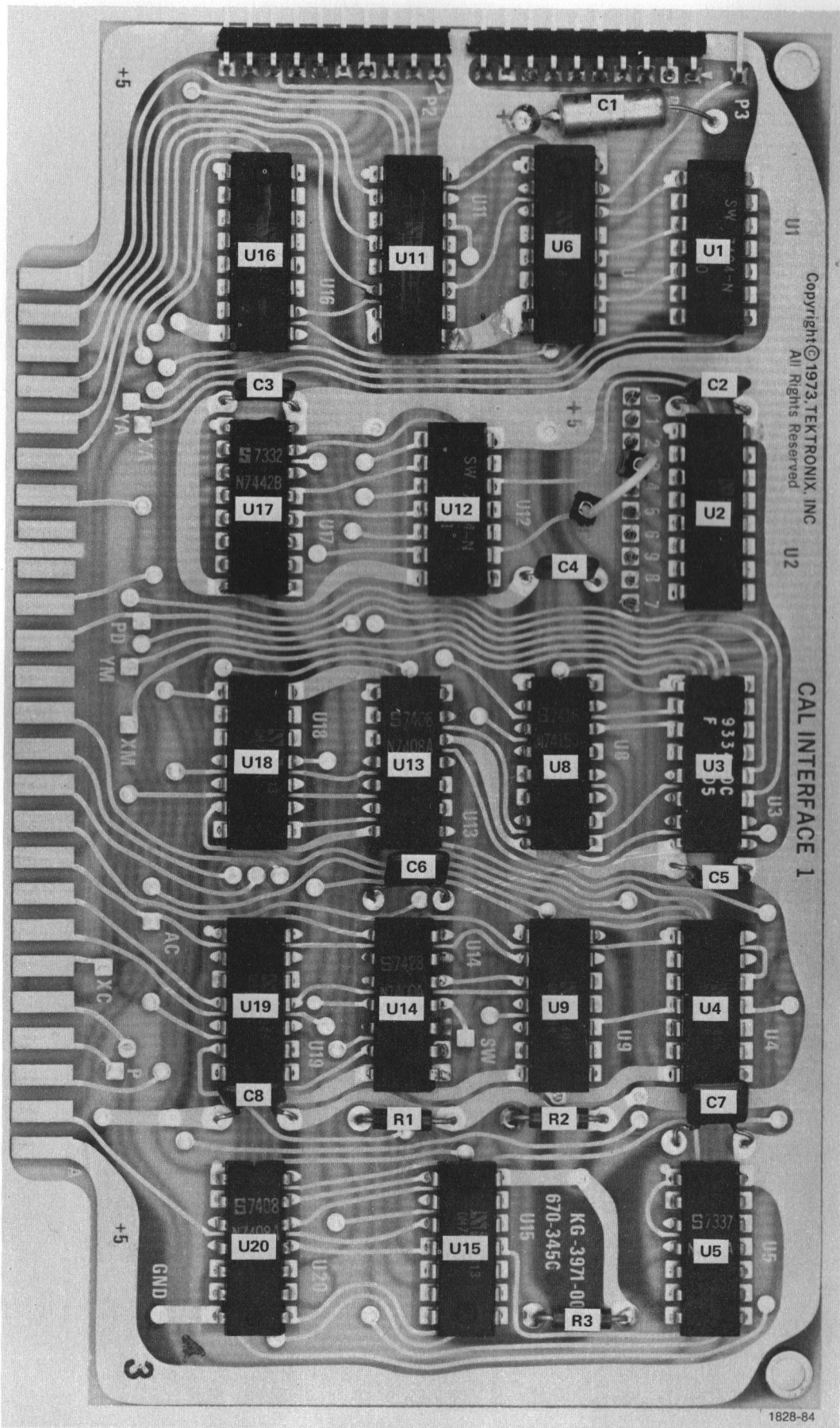
A12 CAL INTERFACE #2  
670-3457  
KC3972

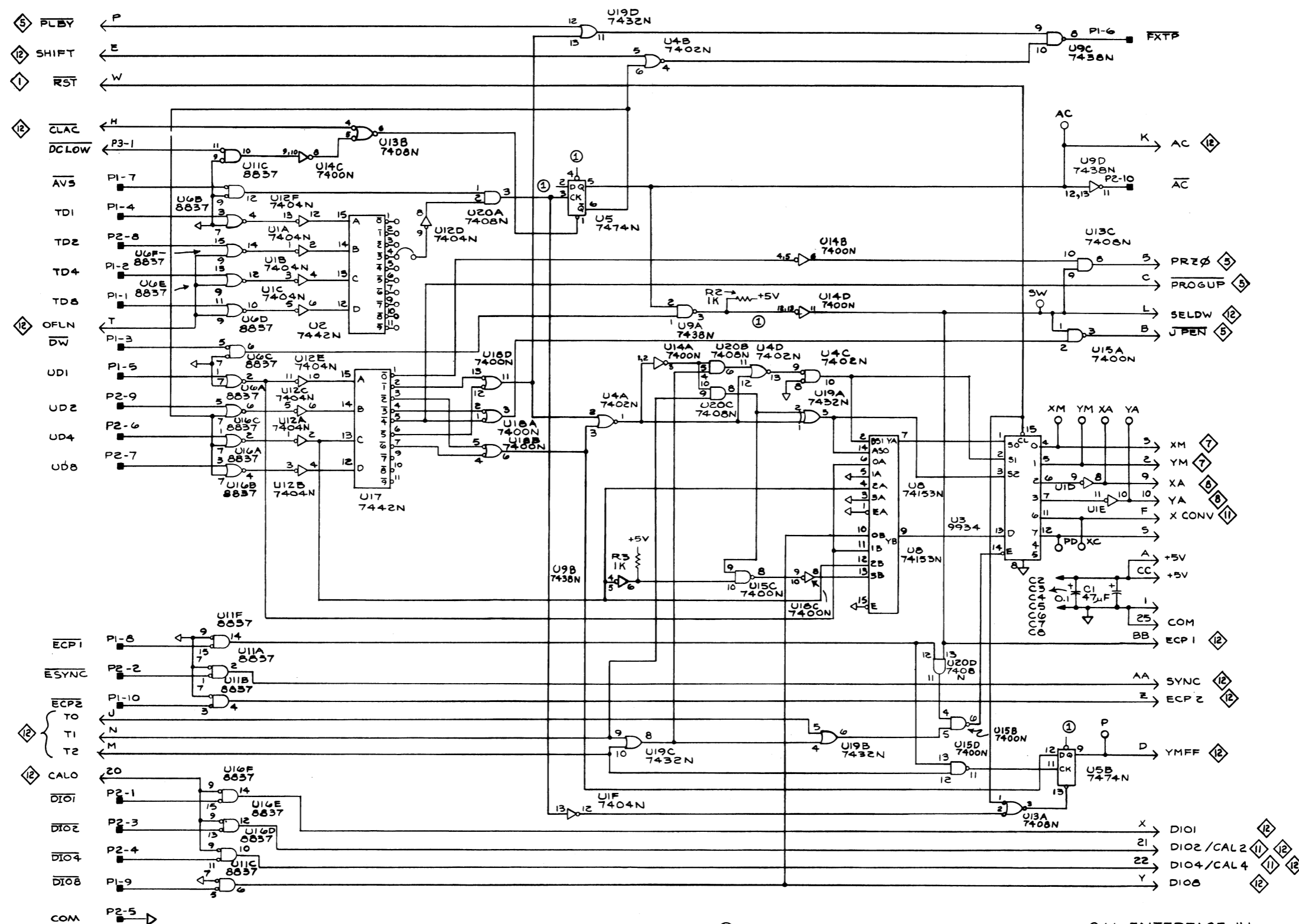
4661

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4661

+5V — R1 1K — TO ①

⑬

CAL INTERFACE #1  
670-3456-01  
388-3971-01  
KG3971

# REPLACEABLE MECHANICAL PARTS

## PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

## SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number  
00X Part removed after this serial number

## FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

## INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

```

1 2 3 4 5      Name & Description
Assembly and/or Component
Attaching parts for Assembly and/or Component
    --- * ---
Detail Part of Assembly and/or Component
Attaching parts for Detail Part
    --- * ---
Parts of Detail Part
Attaching parts for Parts of Detail Part
    --- * ---
  
```

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol --- \* --- indicates the end of attaching parts.

**Attaching parts must be purchased separately, unless otherwise specified.**

## ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

## ABBREVIATIONS

"	INCH	ELCTRN	ELECTRON	IN	INCH	SE	SINGLE END
#	NUMBER SIZE	ELEC	ELECTRICAL	INCAND	INCANDESCENT	SECT	SECTION
ACTR	ACTUATOR	ELCTLT	ELECTROLYTIC	INSUL	INSULATOR	SEMICON	SEMICONDUCTOR
ADPTR	ADAPTER	ELEM	ELEMENT	INTL	INTERNAL	SHLD	SHIELD
ALIGN	ALIGNMENT	EPL	ELECTRICAL PARTS LIST	LPHLDR	LAMPHOLDER	SHLDR	SHOULDERED
AL	ALUMINUM	EQPT	EQUIPMENT	MACH	MACHINE	SKT	SOCKET
ASSEM	ASSEMBLED	EXT	EXTERNAL	MECH	MECHANICAL	SL	SLIDE
ASSY	ASSEMBLY	FIL	FILLISTER HEAD	MTG	MOUNTING	SLFLKG	SELF-LOCKING
ATTEN	ATTENUATOR	FLEX	FLEXIBLE	NIP	NIPPLE	SLVG	SLEEVING
AWG	AMERICAN WIRE GAGE	FLH	FLAT HEAD	NON WIRE	NOT WIRE WOUND	SPR	SPRING
BD	BOARD	FLTR	FILTER	OBD	ORDER BY DESCRIPTION	SQ	SQUARE
BRKT	BRACKET	FR	FRAME or FRONT	OD	OUTSIDE DIAMETER	SST	STAINLESS STEEL
BRS	BRASS	FSTNR	FASTENER	OVH	OVAL HEAD	STL	STEEL
BRZ	BRONZE	FT	FOOT	PH BRZ	PHOSPHOR BRONZE	SW	SWITCH
BSHG	BUSHING	FXD	FIXED	PL	PLAIN or PLATE	T	TUBE
CAB	CABINET	GSKT	GASKET	PLSTC	PLASTIC	TERM	TERMINAL
CAP	CAPACITOR	HDL	HANDLE	PN	PART NUMBER	THD	THREAD
CER	CERAMIC	HEX	HEXAGON	PNH	PAN HEAD	THK	THICK
CHAS	CHASSIS	HEX HD	HEXAGONAL HEAD	PWR	POWER	TNSN	TENSION
CKT	CIRCUIT	HEX SOC	HEXAGONAL SOCKET	RCPT	RECEPTACLE	TPG	TAPPING
COMP	COMPOSITION	HLCP	HELICAL COMPRESSION	RES	RESISTOR	TRH	TRUSS HEAD
CONN	CONNECTOR	HLEXT	HELICAL EXTENSION	RGD	RIGID	V	VOLTAGE
COV	COVER	HV	HIGH VOLTAGE	RLF	RELIEF	VAR	VARIABLE
CPLG	COUPLING	IC	INTEGRATED CIRCUIT	RTNR	RETAINER	W/	WITH
CRT	CATHODE RAY TUBE	ID	INSIDE DIAMETER	SCH	SOCKET HEAD	WSHR	WASHER
DEG	DEGREE	IDNT	IDENTIFICATION	SCOPE	OSCILLOSCOPE	XFMR	TRANSFORMER
DWR	DRAWER	IMPLR	IMPELLER	SCR	SCREW	XSTR	TRANSISTOR

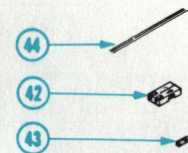
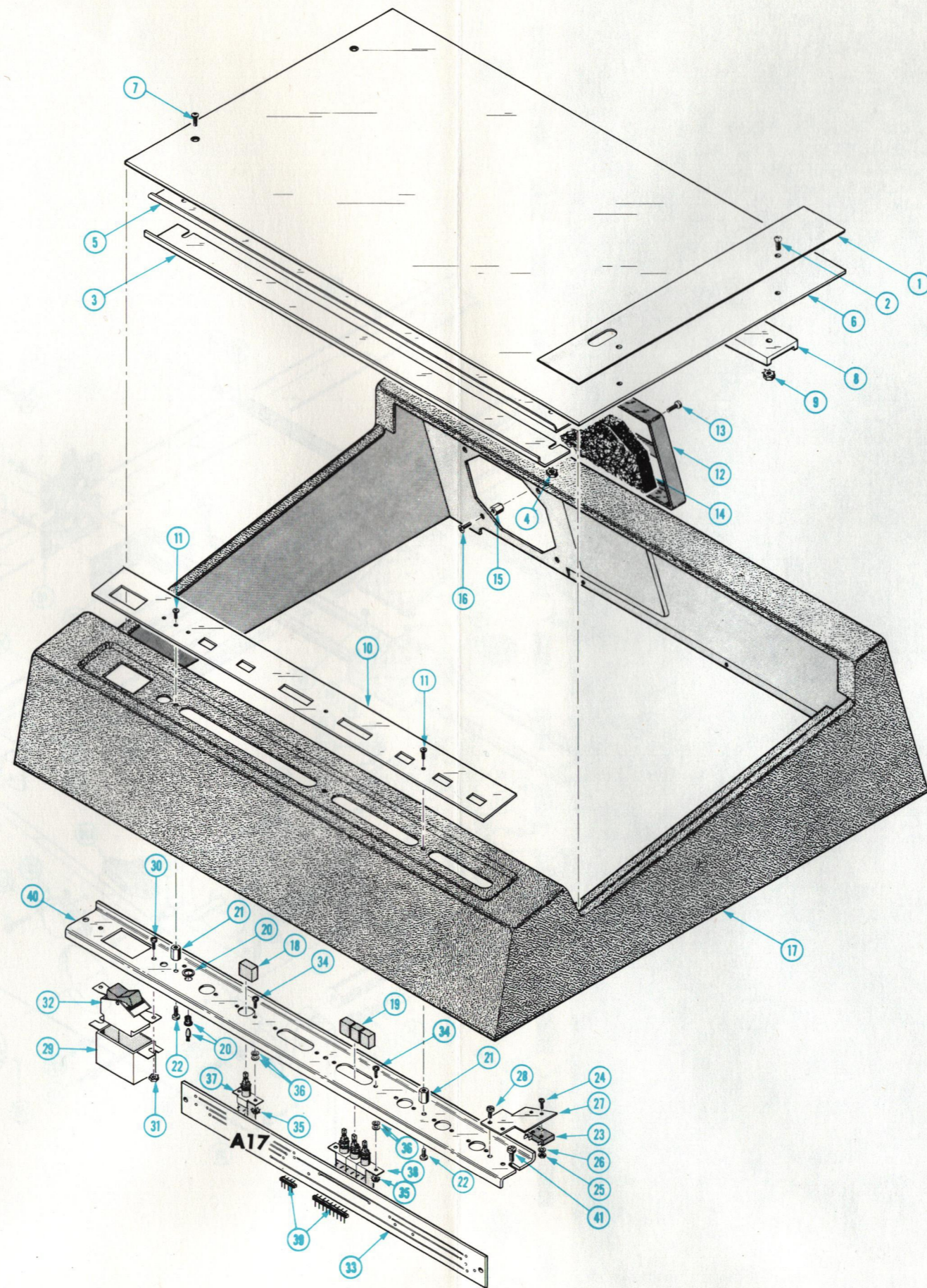
## CROSS INDEX MFR. CODE NUMBER TO MANUFACTURER

MFR.CODE	MANUFACTURER	ADDRESS	CITY,STATE,ZIP
00779	AMP, Inc.	P. O. Box 3608	Harrisburg, PA 17105
01963	Cherry Electrical Products Corp.	3600 Sunset Ave.	Waukegan, IL 60085
04713	Motorola, Inc., Semiconductor Products Div.	5005 E. McDowell Rd.	Phoenix, AZ 85036
04867	Jones, Hiram, Electronics Co.	11607 Vanowen St.	Hollywood, CA 91605
05574	Viking Industries, Inc.	9324 Topanga Canyon Blvd.	Chatsworth, CA 91311
07111	Pneumo Dynamics Corp.	4800 Prudential Tower	Boston, MA 04103
08261	Spectra-Strip Corp.	7100 Lampson Ave.	Garden Grove, CA 92642
08928	Abbott Screw and Mfg. Co.	6525 North Clark	Chicago, IL 60626
12327	Freeway Corp.	9301 Allen Dr.	Cleveland, OH 44125
12360	Albany Products Co., Div. of Pneumo Dynamics Corp.	351 Connecticut Ave.	South Norwalk, CT 06856
21335	Fafnir Bearing Co., Division of Textron Inc., The	37 Booth St.	New Britain, CT 06050
22526	Berg Electronics, Inc.	Youk Expressway	New Cumberland, PA 17070
23499	Gavitt Wire and Cable, Division of RSC Industries, Inc.	455 N. Quince St.	Escondido, CA 92025
23589	Nippon Miniature Bearing Co., LTD		Tokyo, Japan
27193	Cutler-Hammer, Inc.	4201 N. 27th St.	Milwaukee, WI 53216
32674	Graphic Controls Corp., Technical Products and Instruments Div.	P. O. Box 655	Cherry Hill, NJ 08034
42838	National Rivet and Mfg. Co.	1-21 East Jefferson St.	Waupun, WI 53963
70318	Allmetal Screw Products Co., Inc.	821 Stewart Ave.	Garden City, NY 11530
70958	Bergen Wire Rope Co.	1234 Gregg St.	Lodi, NJ 07644
71041	Boston Gear, Div. of Murray Co of Texas Inc.	14 Hayward St.	Quincy, MA 02171
71590	Centralab Electronics, Div. of Globe-Union, Inc.	5757 N. Green Bay Ave.	Milwaukee, WI 53201
71838	Standard Pressed Steel Co., Cleveland Cap Screw Div.	4444 Lee Rd.	Cleveland, OH 44128
73743	Fischer Special Mfg. Co.	446 Morgan St.	Cincinnati, OH 45206
74445	Holo-Krome Co.	31 Brook St. West	Hartford, CT 06110
75915	Littelfuse, Inc.	800 E. Northwest Hwy	Des Plaines, IL 60016
77250	Pheoll Manufacturing Co., Division of Allied Products Corp.	5700 W. Roosevelt Rd.	Chicago, IL 60650
78189	Illinois Tool Works, Inc. Shakeproof Division	St. Charles Road	Elgin, IL 60120
78277	Sigma Instruments Inc.	170 Pearl Street	South Braintree, MA 02185
79136	Waldes, Kohinoor, Inc.	47-16 Austel Place	Long Island City, NY 11101
79963	Zierick Mfg. Co.	Radio Circle	Mt. Kisco, NY 10549
80009	Tektronix, Inc.	P. O. Box 500	Beaverton, OR 97077
81840	Ledex Div., Ledex Inc.	123 Webster St.	Dayton, OH 45402
82877	Rotron, Inc.	7-9 Hasbrouck Lane	Woodstock, NY 12498
83385	Central Screw Co.	2530 Crescent Dr.	Broadview, IL 60153
86445	Penn Fibre and Specialty Co., Inc.	2032 E. Westmoreland St.	Philadelphia, PA 19134
89663	Reese, J. Ramsey, Inc.	71 Murray St.	New York, NY 10007
91260	Conner Spring and Mfg. Co.	1729 Junction Ave.	San Jose, CA 95112
91506	Augat, Inc.	33 Perry Ave.	Attleboro, MA 02703
91741	Nashua Corp., Gubelman Charts Div.	100 East Kinney St.	Newark, NJ 07105
95987	Weckesser Co., Inc.	4444 West Irving Park Rd.	Chicago, IL 60641
96881	Thomson Industries Inc.	1029 Plandome Road	Manhasset, NY 11030
98159	Rubber Teck, Inc.	19115 Hamilton Ave.	Gardena, CA 90247

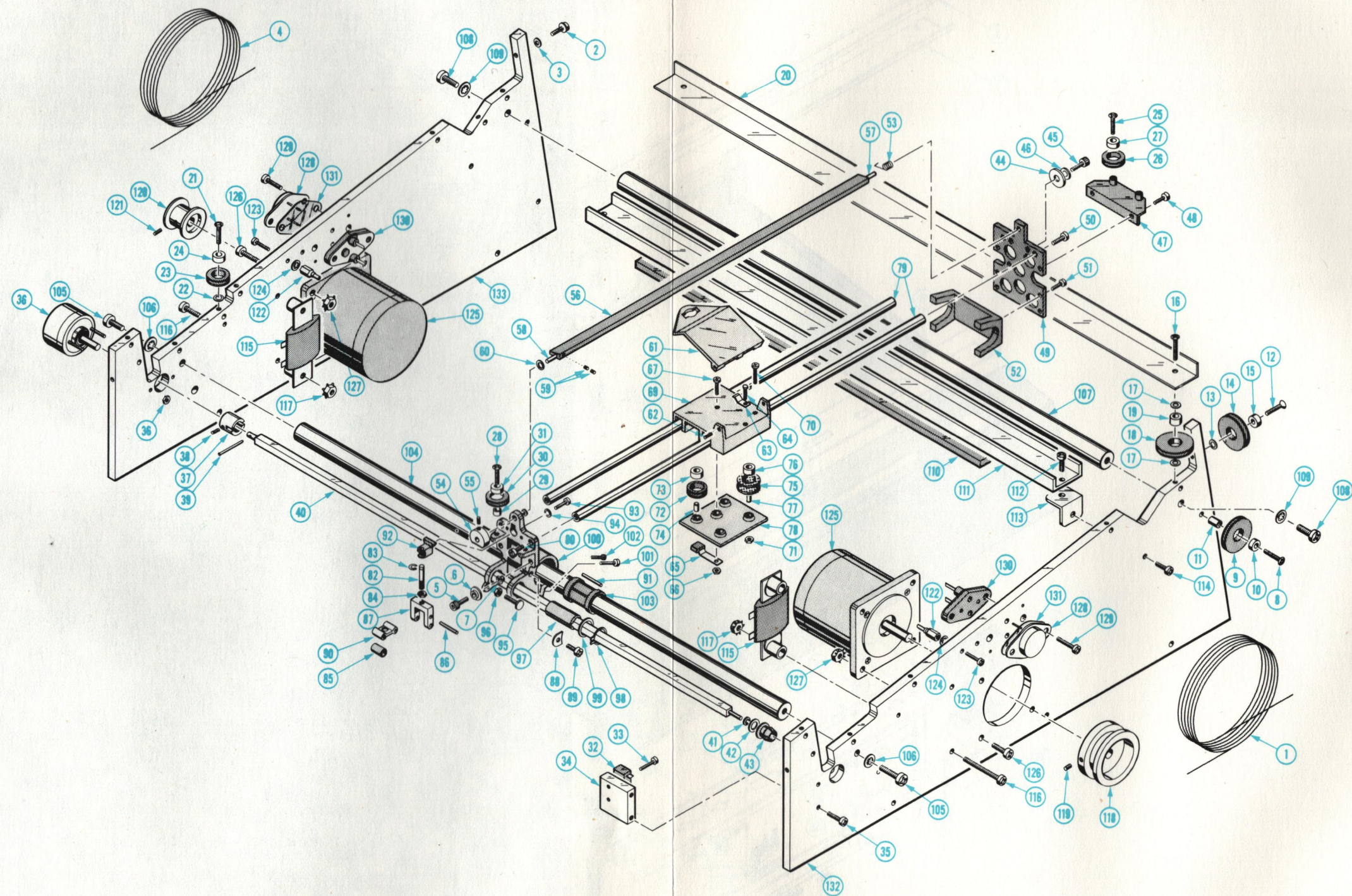
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-1	386-3131-00		1		PLATE, TRIM: RIGHT (ATTACHING PARTS)	80009	386-3131-00
-2	211-0098-00		2		SCREW, CAP: 4-40 X 0.375", SOC BUT HD - - - * - - -	74445	OBD
-3	124-0303-00		1		STRIP, TRIM: FRONT	80009	124-0303-00
-4	210-0458-00		3		NUT, PLAIN, EXT W: 8-32 X 0.344 INCH, STL	83385	OBD
-5	351-0429-00		1		GUIDE, PAPER: PLATEN	80009	352-0429-00
-6	-----		1		CKT BD ASSY: ELECTROSTATIC HOLDDOWN (SEE A16 EPL) (ATTACHING PARTS)		
-7	211-0227-00		2		SCREW, MACHINE: 4-40 X 0.25" SOC BUT HD - - - * - - -	74445	OBD
-8	386-3115-00		2		. CKT BOARD ASSY INCLUDES: . SUPPORT, PLATEN: (ATTACHING PARTS FOR EACH)	80009	386-3115-00
-9	210-0458-00		7		. NUT, PLAIN, EXT W: 8-32 X 0.344 INCH STL - - - * - - -	83385	OBD
-10	333-1884-00		1		PANEL, FRONT: (ATTACHING PARTS)	80009	333-1884-00
-11	211-0227-00		3		SCREW, MACHINE: 4-40 X 0.25" SOC BUT HD - - - * - - -	74445	OBD
-12	380-0410-00		1		HOUSING, FILTER: FAN (ATTACHING PARTS)	80009	380-0410-00
-13	211-0504-00		4		SCREW, MACHINE: 6-32 X 0.25 INCH, PNH STL - - - * - - -	83385	OBD
-14	378-0053-00		1		FILTER ELEM, AIR:	80009	378-0053-00
-15	385-0080-00		4		SPACER, POST: (ATTACHING PARTS FOR EACH)	80009	385-0080-00
-16	211-0538-00		1		SCREW, MACHINE: 6-32 X 0.312" 100 DEG, FLH STL - - - * - - -	83385	OBD
-17	380-0398-01		1		HOUSING, PLOTTER: PTD (ATTACHING PARTS)	80009	380-0398-01
	211-0098-00		3		SCREW, CAP: 4-40 X 0.375" SOC BUT HD - - - * - - -	74445	OBD
-18	366-1162-00		5		PUSHBUTTON: 0.523 W X 0.43" L, MOLD GY	80009	366-1162-00
-19	366-1351-16		6		PUSHBUTTON: 0.213 W X 0.43" L, MOLD GY	71590	352305-03807
-20	-----		-		LAMP, LED: RED, 2V, 100MA (SEE DS1030, DS1032 EPL)		
-21	129-0517-00		3		SPACER, POST: 0.25 L X 0.25 HEX, AL (ATTACHING PARTS FOR EACH)	80009	129-0517-00
-22	211-0008-00		1		. SCREW, MACHINE: 4-40 X 0.25 INCH, PNH STL - - - * - - -	83385	OBD
-23	260-1309-00		1		SWITCH, PUSH: SPDT, 5A, 250 VAC (ATTACHING PARTS)	01963	E63-10H
-24	211-0185-00		2		SCREW, MACHINE: 2-56 X 0.438", PNH, STL	07111	OBD
-25	210-0405-00		2		NUT, PLAIN, HEX.: 2-56 X 0.188 INCH, BRS	73743	2X12157-402
-26	210-0001-00		2		WASHER, LOCK: INTL, 0.092 ID X 0.18" OD, STL - - - * - - -	78189	1202-00-00-0541C
-27	407-1558-00		1		BRACKET, SWITCH: Y-AXIS (ATTACHING PARTS)	80009	407-1558-00
-28	211-0008-00		2		SCREW, MACHINE: 4-40 X 0.250 INCH, PNH STL - - - * - - -	83385	OBD
-29	200-1704-00		1		COVER, PROT: SWITCH (ATTACHING PARTS)	80009	200-1704-00
-30	211-0097-00		2		SCREW, MACHINE: 4-40 X 0.312 INCH, PNH STL	83385	OBD
-31	210-0586-00		2		NUT, PLAIN, EXT W: 4-40 X 0.25 INCH, STL - - - * - - -	78189	OBD
-32	260-1179-00		1		SWITCH, TOGGLE: DPST, 10A, 250 VAC	27193	8931K162
-33	-----		1		CKT BOARD ASSY: PANEL SWITCH (SEE A17 EPL) (ATTACHING PARTS)		
-34	211-0097-00		14		SCREW, MACHINE: 4-40 X 0.312 INCH, PNH STL	83385	OBD
-35	210-0586-00		14		NUT, PLAIN, EXT W: 4-40 X 0.25 INCH, STL	78189	OBD
-36	210-0994-00		28		WASHER, FLAT: 0.125 ID X 0.25" OD, STL - - - * - - -	83385	OBD
	342-0250-00		1		INSULATOR, SW: POWER, 1.10 X 0.820", FBR PPR	80009	342-0250-00

# Mechanical Parts List—4661

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-	-----	-----		-		. CKT BOARD ASSY INCLUDES:		
-37	260-1665-00			2		. SWITCH,PUSH:PEN & SET ZERO	71590	2KAA010000-673
	260-1666-00			3		. SWITCH,PUSH:XY LOAD	71590	2KAB010000-674
-38	260-1667-00			2		. SWITCH,PUSH:FAST	71590	2KAB030000-XXX
-39	131-1425-00			1		. TERM SET,PIN:R-ANGLE 0.150"L,STRIP OF 36	22526	65521-136
-40	386-3023-00			1		SUBPANEL,FRONT:	80009	386-3023-00
						(ATTACHING PARTS)		
-41	211-0507-00			2		SCREW,MACHINE:6-32 X 0.312 INCH,PNH STL	83385	OBD
						- - - * - - -		
-42	352-0169-02			1		HOLDER,TERM.CON:2 WIRE RED	80009	352-0169-02
	352-0169-07			1		HOLDER,TERM.CON:2 WIRE PURPLE	80009	352-0169-07
-43	131-0707-00			4		CONTACT,ELEC:0.48 L,22-26 AWG WIRE	22526	47439
-44	175-0825-00			FT		WIRE,ELECTRICAL:2 WIRE RIBBON,0.917 FEET L	23499	TEK-175-0825-00



4661 DIGITAL X-Y PLOTTER



4661 DIGITAL X-Y PLOTTER

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
2-1	214-2001-00		FT		WIRE CORD:0.018 OD,11 FT L,PLASTIC COVERED (ATTACHING PARTS)	70958	261
-2	211-0116-00		2		SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS	83385	OBD
-3	210-0994-00		2		WASHER,FLAT:0.125 ID X 0.25" OD,STL - - - * - - -	83385	OBD
-4	214-2002-00		FT		WIRE CORD:0.034 OD,11 FT L,PLASTIC COVERED (ATTACHING PARTS)	70958	90.1
-5	211-0564-00		2		SCREW,CAP,SCH:6-32 X 0.375"L HEX	80009	211-0564-00
-6	210-0886-00		2		WASHER,SHLDR:NYLON	80009	210-0886-00
-7	210-0779-00		2		RIVET,TUBULAR:0.051 OD X 0.115" L - - - * - - -	42838	RA-29952715
	401-0274-01		3		PULLY,GROOVED:W/BEARING (ATTACHING PARTS FOR EACH)	80009	401-0274-01
-8	211-0106-00		1		SCREW,MACHINE:4-40 X 0.625" 100 DEG,FLH STL - - - * - - -	83385	OBD
	-----		-		. PULLY INCLUDES:		
-9	401-0274-00		3		. PULLY,GROOVED:1.0 DIA	80009	401-0274-00
-10	401-0321-00		3		. BRG,BALL,GUIDE:X-Y AXIS	21335	OBD
-11	361-0668-00		1		SPACER,SLEEVE:	80009	361-0668-00
	401-0274-01		5		PULLY,GROOVED:W/BEARING (ATTACHING PARTS FOR EACH)	80009	401-0274-01
-12	211-0025-00		1		SCREW,MACHINE:4-40 X 0.375 100 DEG,FLH STL	83385	OBD
-13	210-0994-00		1		WASHER,FLAT:0.125 ID X 0.25" OD,STL - - - * - - -	83385	OBD
	-----		-		. PULLY INCLUDES:		
-14	401-0274-00		5		. PULLY,GROOVED:1.0 DIA	80009	401-0274-00
-15	401-0321-00		5		. BRG,BALL,GUIDE:X-Y AXIS	21335	A33KDD-3FS50160
	401-0274-01		2		PULLY,GROOVED:W/BEARING (ATTACHING PARTS FOR EACH)	80009	401-0274-01
-16	211-0025-00		1		SCREW,MACHINE:4-40 X 0.375 100 DEG,FLH STL	83385	OBD
-17	210-0994-00		2		WASHER,FLAT:0.125 ID X 0.25" OD,STL - - - * - - -	83385	OBD
	-----		-		. PULLY INCLUDES:		
-18	401-0274-00		2		. PULLY,GROOVED:1.0 DIA	21335	OBD
-19	401-0321-00		2		. BRG,BALL,GUIDE:X-Y AXIS	21335	A33KDD-3FS50160
-20	124-0304-00		1		STRIP,TRIM:	80009	124-0304-00
	401-0279-01		1		PULLY,GROOVED:W/BEARING (ATTACHING PARTS)	80009	401-0279-01
-21	211-0025-00		1		SCREW,MACHINE:4-40 X 0.375 100 DEG,FLH STL	83385	OBD
-22	210-0994-00		1		WASHER,FLAT:0.125 ID X 0.25" OD,STL - - - * - - -	83385	OBD
	-----		-		. PULLY INCLUDES:		
-23	401-0279-00		1		. PULLY,GROOVED:0.500 DIA	80009	401-0279-00
-24	401-0321-00		1		. BRG,BALL,GUIDE:X-Y AXIS	21335	OBD
	401-0279-01		2		PULLY,GROOVED:W/BEARING (ATTACHING PARTS FOR EACH)	80009	401-0279-01
-25	211-0025-00		1		SCREW,MACHINE:4-40 X 0.375 100 DEG,FLH STL - - - * - - -	83385	OBD
	-----		-		. PULLY INCLUDES:		
-26	401-0279-00		2		. PULLY,GROOVED:0.500 DIA	80009	401-0279-00
-27	401-0321-00		2		. BRG,BALL,GUIDE:X-Y AXIS	21335	A33KDD-3FS50160
	401-0279-01		2		PULLY,GROOVED:W/BEARING (ATTACHING PARTS FOR EACH)	80009	401-0279-01
-28	211-0102-00		1		SCREW,MACHINE:4-40 X 0.500,FLH STL	83385	OBD
-29	166-0024-00		1		SPACER,SLEEVE:0.125 ID X 0.188 OD X 0.125" L - - - * - - -	71590	P1646XS
	-----		-		. PULLY INCLUDES:		
-30	401-0279-00		2		. PULLY,GROOVED:0.500 DIA	80009	401-0279-00
-31	401-0321-00		2		. BRG,BALL,GUIDE:X-Y AXIS	21335	A33KDD-3FS50160
-32	260-1683-00		1		SWITCH,PUSH:SPDT,125 VAC (ATTACHING PARTS)	01963	E63-10A
-33	211-0034-00		2		SCREW,MACHINE:2-56 X 0.500,INCH,PNH STL - - - * - - -	83385	OBD

# Mechanical Parts List—4661

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
2-34	391-0127-00		1		BLOCK, MOUNTING: MICROSWITCH (ATTACHING PARTS)	80009	391-0127-00
-35	211-0510-00		2		SCREW, MACHINE: 6-32 X 0.375 INCH, PNH STL - - - * - - -	83385	OBD
	119-0485-01		1		SOLENOID, ELEC:	80009	119-0485-01
-36	119-0485-00		1		. SOLENOID, ELEC: 45 DEGREE RIGHT	81840	H-2117-035
-37	376-0157-00		1		. COUPLING, SHAFT: SLIDE SWITCH (ATTACHING PARTS)	80009	376-0157-00
-38	213-0048-00		2		. SETSCREW: 4-40 X 0.125 INCH, HEX SOC STL - - - * - - -	74445	OBD
-39	214-0273-00		1		. PIN, SPRING: 0.062 OD X 0.438 INCH L, SST	80009	214-0273-00
-40	384-1259-00		1		. SHAFT, CAM SW: PEN ACTUATOR	80009	384-1259-00
-41	386-3215-00		1		SUPPORT, SHAFT: SOLENOID, ALUMINUM BUSHING	80009	386-3215-00
-42	210-1001-00		1		WASHER, FLAT: 0.119 ID X 0.375 INCH OD, BRS	12360	OBD
-43	358-0216-00		1		BUSHING, PLASTIC: 0.257 ID X 0.412 INCH OD	80009	358-0216-00
-44	210-0810-00		1		WASHER, FLAT: 0.125 ID X 0.50 INCH OD, FIBER (ATTACHING PARTS)	86445	OBD
-45	211-0211-00		1		SCREW, MACHINE: 4-40 X 0.188 INCH, CAP. SOC HD	71838	OBD
-46	210-1001-00		1		WASHER, FLAT: 0.119 ID X 0.375 INCH OD, BRS - - - * - - -	12360	OBD
-47	407-1456-00		1		BRACKET, ANGLE: CARRIAGE END (ATTACHING PARTS)	80009	407-1456-00
-48	211-0008-00		2		SCREW, MACHINE: 4-40 X 0.25 INCH, PNH STL - - - * - - -	83385	OBD
-49	386-2831-00		1		PLATE, MOUNTING: CARRIAGE END (ATTACHING PARTS)	80009	386-2831-00
-50	211-0504-00		2		SCREW, MACHINE: 6-32 X 0.25 INCH, PNH STL	83385	OBD
-51	211-0117-00		4		SCREW, MACHINE: 4-40 X 0.312 INCH, PNH SST - - - * - - -	70318	OBD
-52	401-0245-00		1		BEARING, SLEEVE: X-AXIS	80009	401-0245-00
-53	214-2115-00		1		SPR, HLCL, TRSN: 0.135 INCH ID	91260	OBD
-54	401-0300-00		1		CAM, PEN, VAR: (ATTACHING PARTS)	80009	401-0300-00
-55	213-0048-00		2		SETSCREW: 4-40 X 0.125 INCH, HEX SOC STL - - - * - - -	74445	OBD
-56	381-0353-00		1		BAR, PEN ACTG: 0.125 X 2.782 INCHES LONG	80009	381-0353-00
-57	214-2117-00		1		. PIN, PIVOT: LEFT ACTUATOR BAR	80009	214-2117-00
-58	214-2116-00		1		. PIN, PIVOT: RIGHT ACTUATOR BAR (ATTACHING PARTS)	80009	214-2116-00
-59	213-0076-00		2		. SETSCREW: 2-56 X 0.125 INCH, HEX. SOC STL	74445	OBD
-60	210-0994-00		1		WASHER, FLAT: 0.125 ID X 0.25" OD, STL	83385	OBD
	352-0384-01		1		HOLDER ASSY, PEN:	80009	352-0384-01
-61	352-0384-00		1		. SPRING, FLAT: PEN PRESSURE (ATTACHING PARTS)	80009	352-0384-00
-62	213-0022-01		2		. SETSCREW: 4-40 X 0.188, HEX SOC STL - - - * - - -	74445	OBD
-63	214-2060-00		1		. SPRING, FLAT: PEN PRESSURE (ATTACHING PARTS)	80009	214-2060-00
-64	211-0130-00		1		. SCREW, MACHINE: 4-40 X 0.25", HEX HD STL - - - * - - -	83385	OBD
-65	348-0408-00		1		. PAD, PRESSURE: X-AXIS SLIDE	80009	348-0408-00
-66	214-2179-00		1		. SPRING, FLAT: PRESSURE PAD (ATTACHING PARTS)	80009	214-2179-00
-67	211-0081-01		1		. SCREW, MACHINE: 2-56 X 0.562 INCH, PNH STL	80009	211-0071-01
-68	210-0405-00		1		. NUT, PLAIN, HEX.: 2-56 X 0.188 INCH, BRS - - - * - - -	73743	2X12157-402
-69	351-0406-00		1		. SLIDE HALF, PEN: (ATTACHING PARTS)	80009	351-0406-00
-70	214-2222-00		2		. SPR, REINFORCE: 0.120 X 0.300 INCH, SST	80009	214-2222-00
-71	210-0405-00		2		. NUT, PLAIN, HEX.: 2-56 X 0.188 INCH, BRS - - - * - - -	73743	2X12157-402
	401-0279-01		2		. PULLY, GROOVED: W/BEARING	80009	401-0279-01
-72	401-0279-00		1		. . PULLY, GROOVED: 0.500 DIA	80009	401-0279-00

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1	2	3	4	5	Name & Description	Mfr Code	Mfr Part Number
2-73	401-0321-00			1	.	.	BRG,BALL,GUIDE:X-Y AXIS				21335	A33KDD-3FS50160
-74	384-0951-00			2	.	SHAFT CAM,SW:					80009	384-0951-00
	401-0306-01			3	.	ROLLER,SLIDE:W/BEARING					80009	401-0306-01
-75	401-0306-00			3	.	ROLLER,SLIDE:0.52 DIA Y-AXIS					80009	401-0306-00
-76	401-0297-00			1	.	BEARING BALL:					23589	SSR-2ZZR
-77	384-1272-00			2	.	SHAFT,PULLEY:Y-AXIS					80009	384-1272-00
-78	386-3104-00			1	.	PLATE,SL BODY:Y-AXIS					80009	386-3104-00
-79	384-1263-00			2	SHAFT,SLIDE:PEN HOLDER						80009	384-1263-00
						(ATTACHING PARTS FOR EACH)						
-80	211-0504-00			1	SCREW,MACHINE:6-32 X 0.25 INCH,PNH STL						83385	OBD
						- - - - *						
	105-0598-02			1	ACTR,PEN BAR:						80009	105-0598-02
-81	401-0305-00			1	BEARING,SLV:0.125 ID X 0.250 OD X 0.125"L						71041	B24-1
-82	384-0986-00			1	ROD,ACTIVATOR:						80009	384-0986-00
						(ATTACHING PARTS)						
-83	354-0350-00			1	RING,RETAINING:0.073"FREE ID X'0.015"STL						79136	5133-9 MD
						- - - - *						
-84	210-0449-00			1	NUT,PLAIN,HEX.:5-40 X 0.250 INCH,BRS						73743	3030-402
-85	401-0302-00			1	ROLLER,ACTR ROD:						80009	401-0302-00
						(ATTACHING PARTS)						
-86	214-2146-00			1	PIN,STR,HDLS:0.062 OD X 0.60 INCH L,SST						80009	214-2146-00
						- - - - *						
-87	352-0396-01			1	HOLDER,ROLLER:						80009	352-0396-01
						(ATTACHING PARTS)						
	214-2146-00			1	PIN,STR,HDLS:0.062 OD X 0.60 INCH L,SST						80009	214-2146-00
						- - - - *						
-88	343-0493-00			2	RETAINER,SHAFT:						80009	343-0493-00
						(ATTACHING PARTS FOR EACH)						
-89	211-0504-00			1	SCREW,MACHINE:6-32 X 0.25 INCH,PNH STL						83385	OBD
						- - - - *						
-90	214-2101-00			1	LINK,PEN MECH:						80009	214-2101-00
						(ATTACHING PARTS)						
-91	214-2147-00			1	PIN,STR,HDLS:0.062 OD X 0.90 INCH L,SST						80009	214-2147-00
						- - - - *						
-92	105-0598-01			1	ACTR,PEN BAR:						80009	105-0598-01
						(ATTACHING PARTS)						
-93	211-0008-00			1	SCREW,MACHINE:4-40 X 0.25 INCH,PNH STL						83385	OBD
-94	210-0994-00			1	WASHER,FLAT:0.125 ID X 0.25" OD,STL						83385	OBD
						- - - - *						
-95	105-0604-00			1	STOP ACTIVATOR:MICROSWITCH						80009	105-0604-00
-96	210-0407-00			1	NUT,PLAIN,HEX.:6-32 X 0.25 INCH,BRS						73743	3038-0228-402
-97	401-0301-00			1	CAM,PEN ACTR:						80009	401-0301-00
						(ATTACHING PARTS)						
-98	354-0390-00			2	RING,RTG:0.338 FREE ID X 0.025" THK STL						79136	5100-37MD
-99	210-0840-00			2	WASHER,FLAT:0.39 ID X 0.562 INCH OD,STL						89663	644R
						- - - - *						
-100	351-0425-01			1	SLIDE,CARRIAGE:						80009	351-0425-01
						(ATTACHING PARTS)						
-101	211-0225-00			2	SCREW,MACHINE:4-40 X 0.312" SOC HD,STL						71838	OBD
-102	213-0218-00			1	SETSCREW:6-32 X 0.25 INCH,HEX SOC STL						74445	OBD
						- - - - *						
-103	401-0298-00			1	BRG,BALL,LIN-MO:0.51 ID X 0.875 OD X 1.25"						96881	OBD
-104	384-0126-00			1	EXTENSION SHAFT:4.594 INCH O/A LENGTH						08928	A-3417
						(ATTACHING PARTS)						
-105	212-0509-00			2	SCREW,MACHINE:10-32 X 0.625",PNH STL						83385	OBD
-106	210-0010-00			2	WASHER,LOCK:INT,0.20 ID X0.376" OD,STL						78189	1210-00-00-0541C
						- - - - *						
-107	384-0953-00			1	SHAFT,CARRIAGE:						80009	384-0953-00
						(ATTACHING PARTS)						
-108	212-0509-00			2	SCREW,MACHINE:10-32 X 0.625 INCH,PNH STL						83385	OBD
-109	210-0010-00			2	WASHER,LOCK:INT,0.20 ID X0.376" OD,STL						78189	1210-00-00-0541C
						- - - - *						
-110	348-0102-00			1	PAD,CUSHIONING:13.76 INCH LONG(CUT TO FIT)						80009	348-0102-00
-111	381-0357-00			1	BAR,CIRCUIT BD:RETAINING						80009	381-0357-00
						(ATTACHING PARTS)						
-112	211-0504-00			2	SCREW,MACHINE:6-32 X 0.25 INCH,PNH STL						83385	OBD
						- - - - *						

# Mechanical Parts List—4661

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
2-113	407-1580-00		2		BRACKET,ANGLE:CKT BOARD RETAINING (ATTACHING PARTS FOR EACH)	80009	407-1580-00
-114	211-0510-00		1		SCREW,MACHINE:6-32 X 0.375 INCH,PNH STL - - - * - - -	83385	OBD
-115	-----		4		RES.,FXD,WW:(SEE R1010,1012,1020 & 1022 EPL) (ATTACHING PARTS)		
-116	212-0082-00		4		SCREW,MACHINE:8-32 X 1.250 INCH,PNH STL	83385	OBD
-117	210-0458-00		4		NUT,PLAIN,EXT W:8-32 X 0.344 INCH,STL - - - * - - -	83385	OBD
-118	401-0275-00		1		PULLEY,FLAT:Y-AXIS (ATTACHING PARTS)	80009	401-0275-00
-119	213-0022-00		2		SETSCREW:4-40 X 0.188 INCH,HEX SOC STL - - - * - - -	74445	OBD
-120	401-0278-00		1		PULLEY,FLAT:X-AXIS (ATTACHING PARTS)	80009	401-0278-00
-121	213-0048-00		2		SETSCREW:4-40 X 0.125 INCH,HEX SOC STL - - - * - - -	74445	OBD
-122	129-0224-00		4		TERMINAL,STUD:SCREW MT,0.47 INCH LONG (ATTACHING PARTS FOR EACH)	04867	19808
-123	211-0510-00		1		SCREW,MACHINE:6-32 X 0.375 INCH,PNH STL	83385	OBD
-124	210-0006-00		1		WASHER,LOCK:INTL,0.146 ID X 0.283"OD,STL - - - * - - -	78189	1206-00-00-0541C
-125	147-0040-00		2		MOTOR,DC:0.125 SHAFT (ATTACHING PARTS FOR EACH)	78277	20-22230200F6
-126	212-0010-00		4		SCREW,MACHINE:8-32 X 0.625 INCH,PNH STL	83385	OBD
-127	210-0458-00		4		NUT,PLAIN,EXT W:8-32 X 0.344 INCH,STL - - - * - - -	83385	OBD
-128	-----		2		TRANSISTOR:(SEE Q1010 & Q1020 EPL) (ATTACHING PARTS FOR EACH)		
-129	211-0513-00	B010100 B010199	2		SCREW,MACHINE:6-32 X 0.625 INCH,PNH STL	83385	OBD
	211-0551-00	B010200	2		SCREW,MACHINE:6-32 X 0.562 INCH,PNH STL - - - * - - -	83385	OBD
-130	136-0135-00		2		SKT,PL-IN-ELEK:2 PIN (ATTACHING PARTS FOR EACH)	91506	8038-1G8
	211-0034-00	XB010200	2		SCREW,MACHINE:2-56 X 0.500,PNH STL	77250	OBD
	210-0405-00	XB010200	2		NUT,PLAIN,HEX:2-56 X 0.188 INCH BRS	73743	2X12157-402
	210-0001-00	XB010200	2		WASHER,LOCK:INTL,0.092 ID X 0.18" OD STL - - - * - - -	78189	1202-00-00-0541C
-131	386-0978-00		2		INSULATOR,PLATE:0.002 INCH MICA,FOR TO-3	80009	386-0978-00
-132	426-1128-00		1		FRAME SECT,CAB:BOTTOM FRONT	80009	426-1128-00
-133	426-1127-00		1		FRAME SECT,CAB:TOP FRONT	80009	426-1127-00

## Mechanical Parts List—4661

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
3-1	-----	-----	2		CAP.,FXD,ELCTLT:(SEE C1003,C1004 EPL) (ATTACHING PARTS FOR EACH)		
-2	212-0509-00		1		SCREW,MACHINE:10-32 X 0.025 INCH,PNH STL	83385	OBD
-3	210-0010-00		1		WASHER,LOCK:INT,0.20 ID X 0.376" OD,STL	78189	1210-00-0541C
-4	210-0273-00		1		TERMINAL,LUG:0.781 INCH LONG	79963	547
-5	361-0641-00		1		SPACER,INSUL:CAPACITOR REAR - - - * - - -	80009	361-0641-00
-6	407-1517-00		1		BRACKET,ANGLE:CAPACITOR,MTG (ATTACHING PARTS)	80009	407-1517-00
-7	211-0510-00		2		SCREW,MACHINE:6-32 X 0.375 INCH,PNH STL - - - * - - -	83385	OBD
-8	-----	-----	2		SEMICON,DVC DI:(SEE CR1003 & CR1004 EPL) (ATTACHING PARTS FOR EACH)		
-9	211-0551-00		1		SCREW MACHINE:6-32 X 0.562 INCH,PNH STL	83385	NOTE
-10	210-0407-00		1		NUT,PLAIN,HEX.:6-32 X 0.25 INCH,BRS	73743	3038-0228-402
-11	210-0006-00		1		WASHER,LOCK:INTL,0.146 ID X 0.283"OD,STL - - - * - - -	78189	1206-00-00-0541C
-12	255-0334-00		1		PLASTIC CHANNEL:12.75 INCHES LONG	80009	255-0334-00
-13	378-0837-00		1		BAFFLE,AIR: (ATTACHING PARTS)	80009	378-0837-00
-14	211-0198-00		4		SCREW,MACHINE:4-40 X 0.438 INCH,RDH NYLON	77250	OBD
-15	210-0586-00		4		NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL	78189	OBD
-16	211-0097-00		2		SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL - - - * - - -	83385	OBD
-17	343-0005-00		1		CLAMP,LOOP:0.438 INCH (ATTACHING PARTS)	95987	OBD
-18	211-0507-00		1		SCREW,MACHINE:6-32 X 0.312 INCH,PNH STL	83385	OBD
-19	210-0863-00		1		WSHR,LOOP CLAMP:FOR 0.50" WIDE CLAMP,STL - - - * - - -	95987	C191
-20	-----	-----	3		TRANSISTOR:(SEE Q12, Q1 & Q2 EPL) (ATTACHING PARTS FOR EACH)		
-21	211-0014-00		1		SCREW,MACHINE:4-40 X 0.500 INCH,PNH STL - - - * - - -	83385	OBD
-22	-----	-----	2		TRANSISTOR:(SEE Q3 & Q4 EPL) (ATTACHING PARTS FOR EACH)		
-23	211-0014-00		1		SCREW,MACHINE:4-40 X 0.500 INCH,PNH STL	83385	OBD
	210-1122-00		5		WASHER,LOCK:DISHED,0.12 ID X 0.375"OD,STL - - - * - - -	78189	4704-04-02
-24	342-0136-00		5		INSULATOR,WSHR:0.812 OD X 0.003" THK	04713	OBD
-25	214-2007-00		1		HEAT SINK,XSTR: (ATTACHING PARTS)	80009	214-2007-00
-26	211-0514-00		2		SCREW,MACHINE:6-32 X 0.750 INCH,PNH STL	83385	OBD
-27	210-0457-00		2		NUT,PLAIN,EXT W:6-32 X 0.312 INCH,STL - - - * - - -	83385	OBD
-28	-----	-----	1		CKT BOARD ASSY:(SEE A1 EPL) (ATTACHING PARTS)		
-29	211-0116-00		4		SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS - - - * - - -	83385	OBD
-30	131-1191-00		2		. CKT BOARD ASSY INCLUDES: . TERM,QIK DISC:FOR 0.25" WD CONN (ATTACHING PARTS FOR EACH)	00779	42822-2
-31	211-0008-00		1		. SCREW,MACHINE:4-40 X 0.25 INCH,PNH STL	83385	OBD
-32	210-0586-00		1		. NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL - - - * - - -	78189	OBD
-33	131-0589-00		31		. CONTACT,ELEC:0.46 INCH LONL	22526	47350
-34	-----	-----	1		XFMR,PWR:STPDN(SEE T1001 EPL) (ATTACHING PARTS)		
-35	212-0023-00		4		SCREW,MACHINE:8-32 X 0.375 INCH,PNH STL	83385	OBD
-36	210-0008-00		4		WASHER,LOCK:INTL,0.172 ID X 0.331"OD,STL	78189	1208-00-00-0541C
-37	210-0804-00		4		WASHER,FLAT:0.17 ID X 0.375 INCH OD,STL - - - * - - -	12327	OBD
-38	343-0213-00		2		CLAMP,LOOP:PRESS MT,PLASTIC	80009	343-0213-00
-39	210-0202-00		1		TERMINAL,LUG:SE #6 (ATTACHING PARTS)	78189	2104-06-00-2520N
-40	211-0504-00		1		SCREW,MACHINE:6-32 X 0.250",PNH STL - - - * - - -	83385	OBD

# Mechanical Parts List—4661

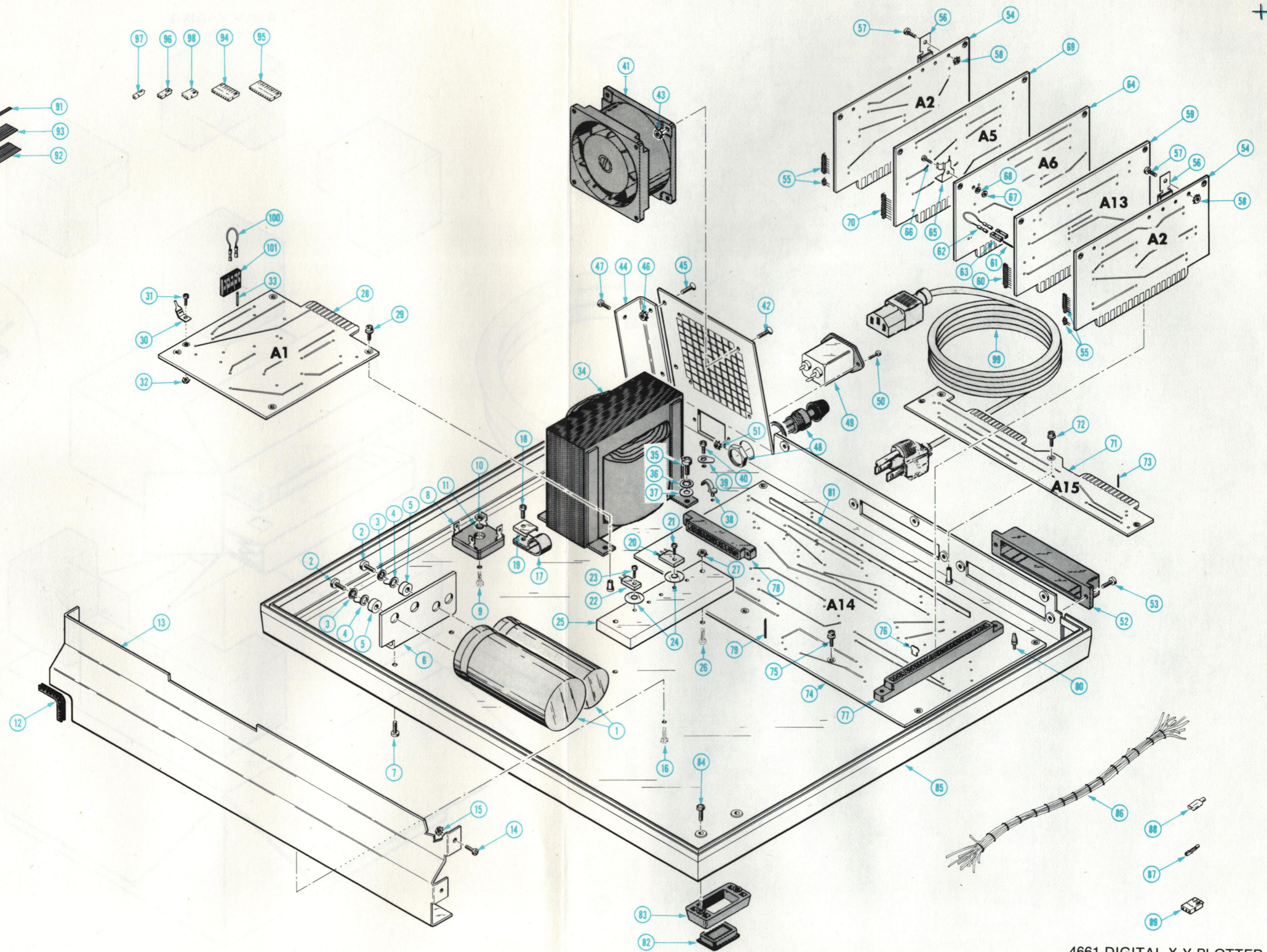
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
3-41	119-0492-00			1		FAN,AXIAL:MUFFIN TYPE,3 INCHES DIA,115V (ATTACHING PARTS)	82877	SP3A2
-42	211-0512-00			4		SCREW,MACHINE:6-32 X 0.50" 100 DEG,FLH STL	83385	OBD
-43	210-0457-00			4		NUT,PLAIN,EXT W:6-32 X 0.312 INCH,STL - - - * - - -	83385	OBD
-44	407-1563-00			1		BRACKET,ANGLE:FAN (ATTACHING PARTS)	80009	407-1563-00
-45	211-0559-00			2		SCREW,MACHINE:6-32 X 0.375"100 DEG,FLH STL	83385	OBD
-46	210-0457-00			2		NUT,PLAIN,EXT W:6-32 X 0.312 INCH,STL	83385	OBD
-47	211-0510-00			2		SCREW,MACHINE:6-32 X 0.375 INCH,PNH STL - - - * - - -	83385	OBD
-48	352-0362-00			1		FUSEHOLDER: W/MOUNTING HARDWARE	75915	345001
-49	119-0389-00			1		FILTER,RAD INT:115/230V,3A (ATTACHING PARTS)	80009	119-0389-00
-50	211-0198-00			2		SCREW,MACHINE:4-40 X 0.438" RDH,NYL	77250	OBD
-51	210-0586-00			2		NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL - - - * - - -	78189	OBD
-52	351-0405-00			2		GUIDE,CONNECTOR: (ATTACHING PARTS FOR EACH)	80009	351-0405-00
-53	211-0510-00			2		SCREW,MACHINE:6-32 X 0.375 INCH,PNH STL - - - * - - -	83385	OBD
-54	-----			2		CKT BOARD ASSY:STEP-DRIVE (SEE A2 EPL)		
-55	131-1425-00			9		. EACH CKT BOARD ASSY INCLUDES:	22526	75521-136
-56	-----			5		. TERM SET,PIN:R ANGLE,0.15"L . TRANSISTOR:(SEE Q4,Q5,Q15,Q16 & Q17 EPL) (ATTACHING PARTS FOR EACH)		
-57	211-0008-00			1		. SCREW,MACHINE:4-40 X 0.25 INCH,PNH STL	83385	OBD
-58	210-0586-00			1		. NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL - - - * - - -	78189	OBD
-59	-----			1		CKT BOARD ASSY:CAL INTERFACE 1(SEE A13 EPL)		
-60	131-1425-00			31		. TERM SET,PIN:R ANGEL,0.150"L	22526	65521-136
-61	131-0608-00			11		. CONTACT,ELEC:0.365 INCH LONG	22526	47357
-62	131-1270-00			1		. LINK,TERM.CONNE:	80009	131-1270-00
-63	131-0707-00			2		. . CONTACT,ELEC:0.48"L,22-26 AWG WIRE	22526	47439
-64	352-0171-00			2		. . HOLDER,TERM.CON:1 WIRE BLACK	80009	352-0171-00
-65	346-0032-00	B010100	B010149	1		CKT BOARD ASSY:TIMING(SEE A6 EPL) STRAP,RETAINING:MOLDED RUBBER	98159	2829-75-4
-66	136-0208-00	B010150		1		. SOCKET,PLUG-IN:CRYSTAL AUGAT (ATTACHING PARTS)	91506	8004-1G5
-67	211-0022-00	XB010150		2		. SCREW,MACHINE:2-56 X 0.188 INCH,PNH STL	83385	OBD
-68	210-0405-00	XB010150		2		. NUT,PLAIN,HEX.:2-56 X 0.188 INCH,BRS	73743	2X12157-402
-69	210-0001-00	XB010150		2		. WASHER,LOCK:INTL,0.092 ID X 0.18"OD,STL - - - * - - -	78189	1202-00-00-0541C
-70	-----			1		CKT BOARD ASSY:PANEL INTERFACE(SEE A5 EPL)		
-71	131-1425-00			20		. TERM SET,PIN:R ANGLE,0.150"L	22526	65521-136
-72	131-0993-09			2		. LINK,TERM CONN:WHITE	00779	530153-1
-73	-----			1		CKT BOARD ASSY:I.O(SEE A15 EPL) (ATTACHING PARTS)		
-74	211-0116-00			3		SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS - - - * - - -	83385	OBD
-75	-----			-		. CKT BOARD ASSY INCLUDES:		
-76	131-0608-00			21		. CONTACT,ELEC:0.365 INCH LONG	22526	47357
-77	-----			1		CKT BOARD ASSY:MOTHER(SEE A14 EPL) (ATTACHING PARTS)		
-78	211-0116-00			8		SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS - - - * - - -	83385	OBD
-79	-----			-		. CKT BOARD ASSY INCLUDES:		
-80	214-1458-00			13		. KEY,CONNECTOR:	05574	091-0071-00
-81	131-1613-00			13		. CONTACT,ELEC:PUSH SWITCH	80009	131-1613-00
-82	131-1009-00			1		. CONN,RCPT,ELEC:18/36 CONTACTS	05574	3VH18/1CN-3
-83	131-0589-00			15		. CONTACT,ELEC:0.46 INCH LONG	22526	47350
-84	386-1557-00			2		. SPACER,CKT BD:PLASTIC	80009	386-1557-00



## Mechanical Parts List—4661

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
3-81	124-0301-00		4		. TERM STRIP,GND:CKT BD MT,6 TABS,BRASS	80009	124-0301-00
	124-0302-00		4		. TERM,STRIP,GND:CKT BD MT,14 TABS,BRASS	80009	124-0302-00
-82	348-0177-00		4		PAD,CUSHIONING:1.25 W X 0.50 INCH H	80009	348-0177-00
-83	348-0178-00		4		FOOT,CABINET:2 W X 0.40 INCH H	80009	348-0178-00
					(ATTACHING PARTS FOR EACH)		
-84	213-0054-00		2		SCR,TPG,THD FOR:6-32 X 0.312 INCH,PNH STL	83385	OBD
	210-0803-00		2		WASHER,FLAT:0.15 ID X 0.375 INCH OD,STL	12327	OBD
					- - - - *		
-85	432-0101-01		1		BASE,PLOTTER	80009	432-0101-01
-86	179-2258-00		1		WIRING HARNESS:AC	80009	179-2258-00
-87	131-0792-00		4		. CONTACT,ELEC:0.577"L,18-20AWG WIRE	22526	46221
-88	131-1159-00		4		. CONN,RCPT,ELEC:250 FASTEN	00779	60041-2
-89	352-0199-02		1		. HLD,TERM CONN:3 WIRE,RED	80009	352-0199-02
	352-0199-03		1		. HOLDER,TERM.CON:3 WIRE ORANGE	80009	352-0199-03
	179-2259-00		1		WIRING HARNESS:POWER	80009	179-2259-00
	131-0792-00		3		. CONTACT,ELEC:0.577"L,18-20AWG WIRE	22526	46221
	131-1215-00		3		. TERM,QIK DISC:CRIMP MT W/RED INS	00779	42628-2
	131-1216-00		2		. TERM,QIK DISC:CRIMP MT W/BLUE INS	00779	42332-2
	352-0199-01		1		. HOLDER,TERM.CON:3 WIRE BROWN	80009	352-0199-01
-90	131-0621-00		21		CONTACT,ELEC:0.577"L,22-26 AWG WIRE	22526	46231
	131-0707-00		100		CONTACT,ELEC:0.48"L,22-26 AWG WIRE	22526	47439
-91	175-0825-00		FT		WIRE,ELECTRICAL:2 WIRE RIBBON,0.917 FT	23499	TEK-175-0825-00
-92	175-0833-00		FT		WIRE,ELECTRICAL:10 WIRE RIBBON,4.833 FT	23499	TEK-175-0833-00
-93	175-0858-00		FT		. CABLE,SP,ELEC:7 WIRE RIBBON,1.500 FT	08261	OBD
-94	352-0165-00		2		HOLDER,TERM.CON:7 WIRE BLACK	80009	352-0165-00
-95	352-0168-01		2		HOLDER,TERM.CON:10 WIRE BROWN	80009	352-0168-01
	352-0168-02		2		HOLDER,TERM.CON:10 WIRE RED	80009	352-0168-02
	352-0168-03		2		HOLDER,TERM.CON:10 WIRE ORANGE	80009	352-0168-03
	352-0168-04		2		HOLDER,TERM.CON:10 WIRE YELLOW	80009	352-0168-04
	352-0198-05		1		HOLDER,TERM.CON:10 WIRE GREEN	80009	352-0198-05
-96	352-0169-02		1		HOLDER,TERM.CON:2 WIRE RED	80009	352-0169-02
	352-0169-07		1		HOLDER,TERM.CON:2 WIRE PURPLE	80009	352-0169-07
-97	352-0171-00		2		HOLDER,TERM.CON:1 WIRE BLACK	80009	352-0171-00
-98	352-0199-06		1		. HOLDER,TERM.CON:3 WIRE BLUE	80009	352-0199-06
-99	161-0066-01		1		CABLE ASSY PWR:98 INCHES LONG	80009	161-0066-01
	131-1704-00		1		LINK,TERM CONN:GRAY,18 AWG 220V	80009	131-1704-00
-100	131-0792-00		2		. CONTACT,ELEC:0.577"L,18-20AWG WIRE	22526	46221
-101	352-0201-00		1		. HOLDER,TERM.CON:5 WIRE BLACK	80009	352-0201-00
	-----		1		CKT BOARD ASSY:PROGRAMMER(SEE A7 EPL)		
	131-0993-09		1		. LINK,TERM.CONN:WHITE	00779	530153-1





4661 DIGITAL X-Y PLOTTER

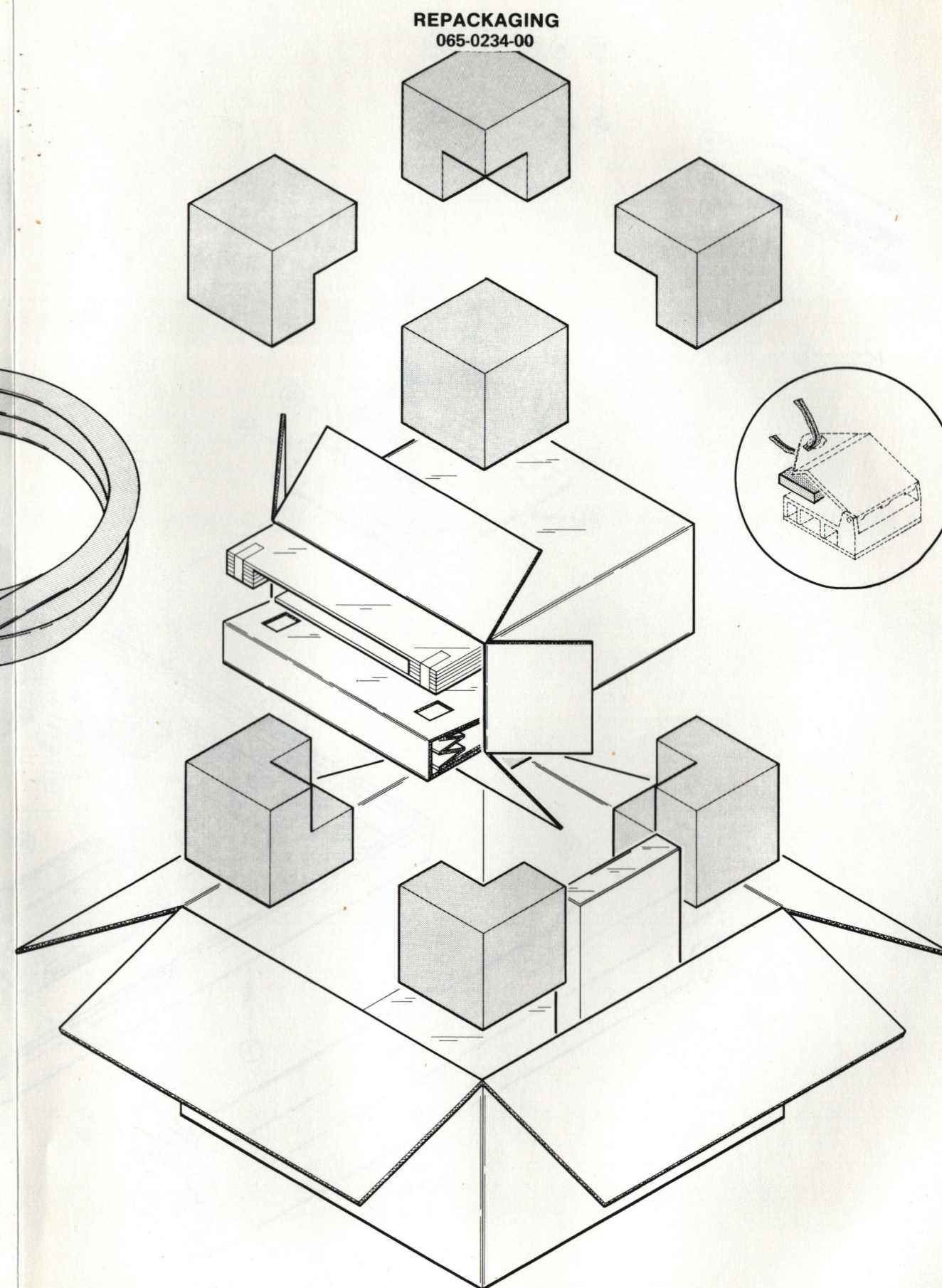
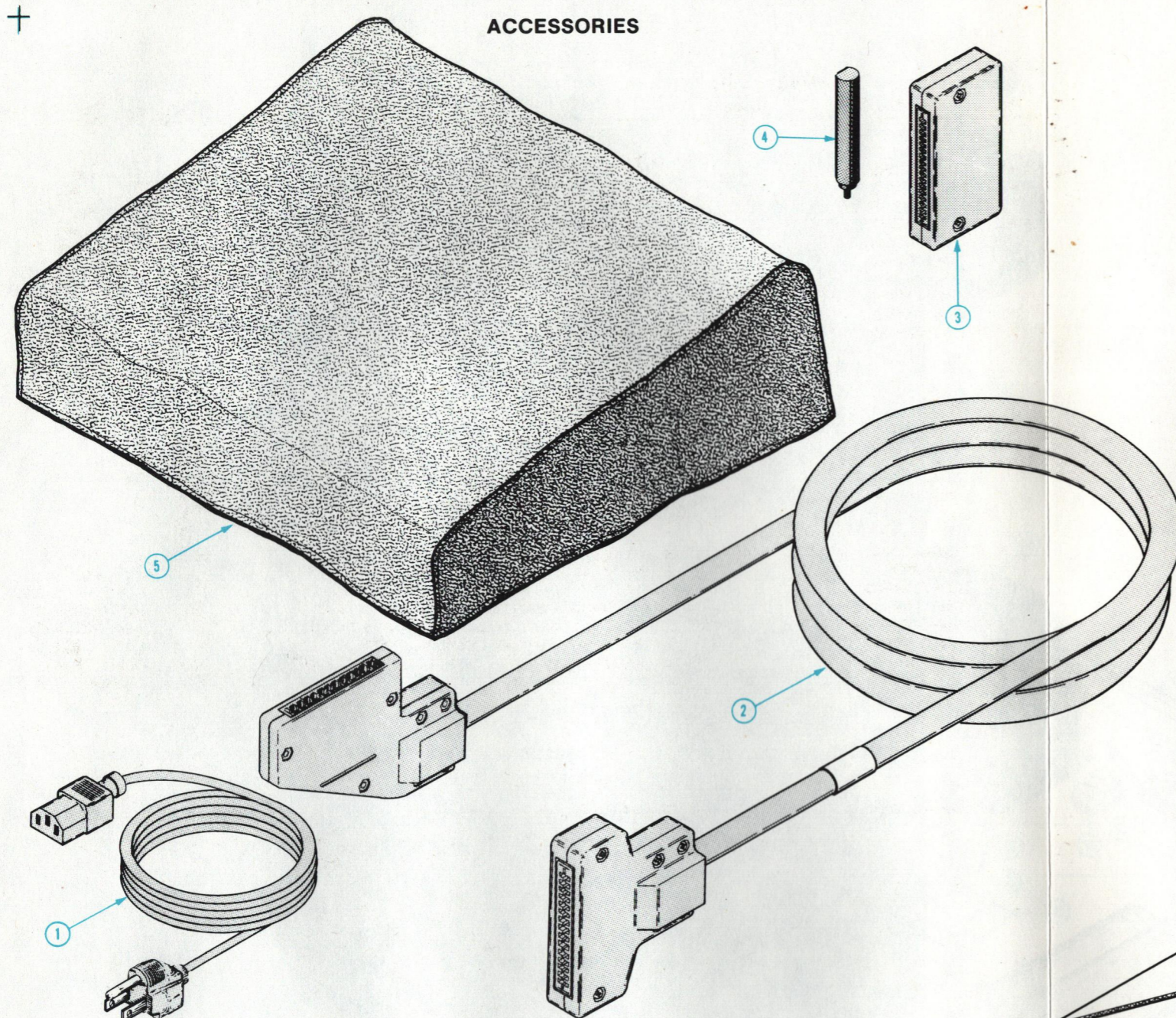


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Qty	1	2	3	4	5	Name & Description	Mfr Code	Mfr Part Number
STANDARD ACCESSORIES											
4 -1	161-0066-00		1						CABLE ASSY,PWR:3 WIRE,98 INCH LONG	80009	161-0066-00
-2	012-0498-00		1						CABLE,ASSY,SP:2 FEET,6 INCHES LONG	80009	012-0498-00
-3	016-0567-00		1						TERM,CALCULATOR:	80009	016-0567-00
-4	016-0589-00		1						PEN RECORDER:RED,DISPOSABLE 3/PACKAGE	32674	82-17-0012-03
	016-0589-01		1						PEN RECORDER:GREEN,DISPOSABLE 3/PACKAGE	32674	82-17-0014-03
	016-0589-02		1						PEN RECORDER:BLACK,DISPOSABLE 3/PACKAGE	32674	82-17-0011-03
	016-0589-03		1						PEN RECORDER:BLUE,DISPOSABLE 3/PACKAGE	32674	82-17-0013-03
	006-1698-00		1						CHART,RCDG,INST:11 X 16.5",10 X 10 TO 1"	91741	OBD
-5	016-0593-00		1						COVER,PROT:X-Y PLOTTER	80009	016-0593-00
	070-1804-00		1						MANUAL,TECH:OPERATORS (NOT SHOWN)	80009	070-1804-00

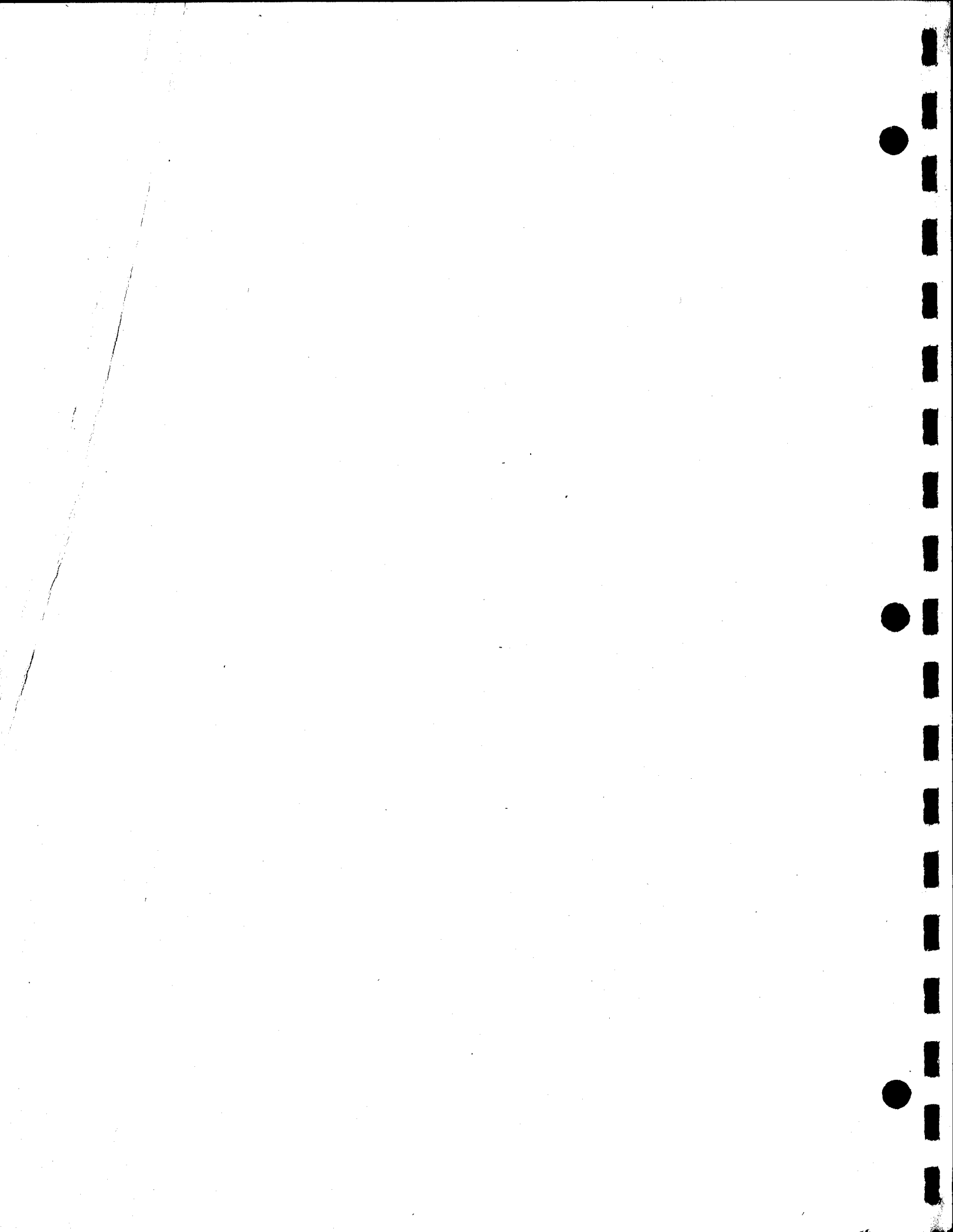
## OPTIONAL ACCESSORIES (NOT SHOWN)

006-1698-00	1	CHART,RCDG INST:11 X 16.5",10 X 10 TO 1"	91741	OBD
006-1699-00	1	CHART,RCDG INST:11 X 16.5",10 X 10 TO 1 CM	91741	OBD
006-1700-00	1	CHART,RCDG INST:11 X 16.5",3 CYCLES X 10"	91741	OBD
006-1701-00	1	CHART,RCDG INST:11 X 16.5",2 CYCLES X 15"	91741	OBD
006-1702-00	1	CHART,RCDG INST:11 X 16.5",2 CYCLES X 3 CYCLES	91741	OBD
012-0498-01	1	CABLE,ASSY,SP E:7 FEET LONG	80009	012-0498-01
012-0499-00	1	CABLE,ASSY,SP E:2 FEET 6 INCHES LONG	80009	012-0499-00
012-0499-01	1	CABLE,ASSY,SP E:7 FEET LONG	80009	012-0499-01
016-0589-00	1	PEN RECORDER:RED,DISPOSABLE 3/PACKAGE	32674	82-17-0012-03
016-0589-01	1	PEN RECORDER:GREEN,DISPOSABLE 3/PACKAGE	32674	82-17-0014-03
016-0589-02	1	PEN RECORDER:BLACK,DISPOSABLE 3/PACKAGE	32674	82-17-0011-03
016-0589-03	1	PEN RECORDER:BLUE,DISPOSABLE 3/PACKAGE	32674	82-17-0013-03
062-1672-10 <sup>1</sup>	1	SOFTWARE,PKG:4661 SUPPORT W/MAGE CRTG PKG	80009	062-1672-10
070-1828-00	1	MANUAL,TECH:SERVICE	80009	070-1828-00

## REPACKAGING

5 -	065-0234-00		1						CARTON ASSY:	80009	065-0234-00
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<sup>1</sup>Supplied with Tek31 at no additional charge.



## MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.



- 5 PLSBY
- 12 SHIFT
- 1 RST
- 12 CLAC

addresses  
valid  
stroke timer

TD1  
TD2  
TD4  
TD8

- 12 OFLN

low in  
1 cycle after  
Esync

UD1  
UD2  
UD4  
UD8

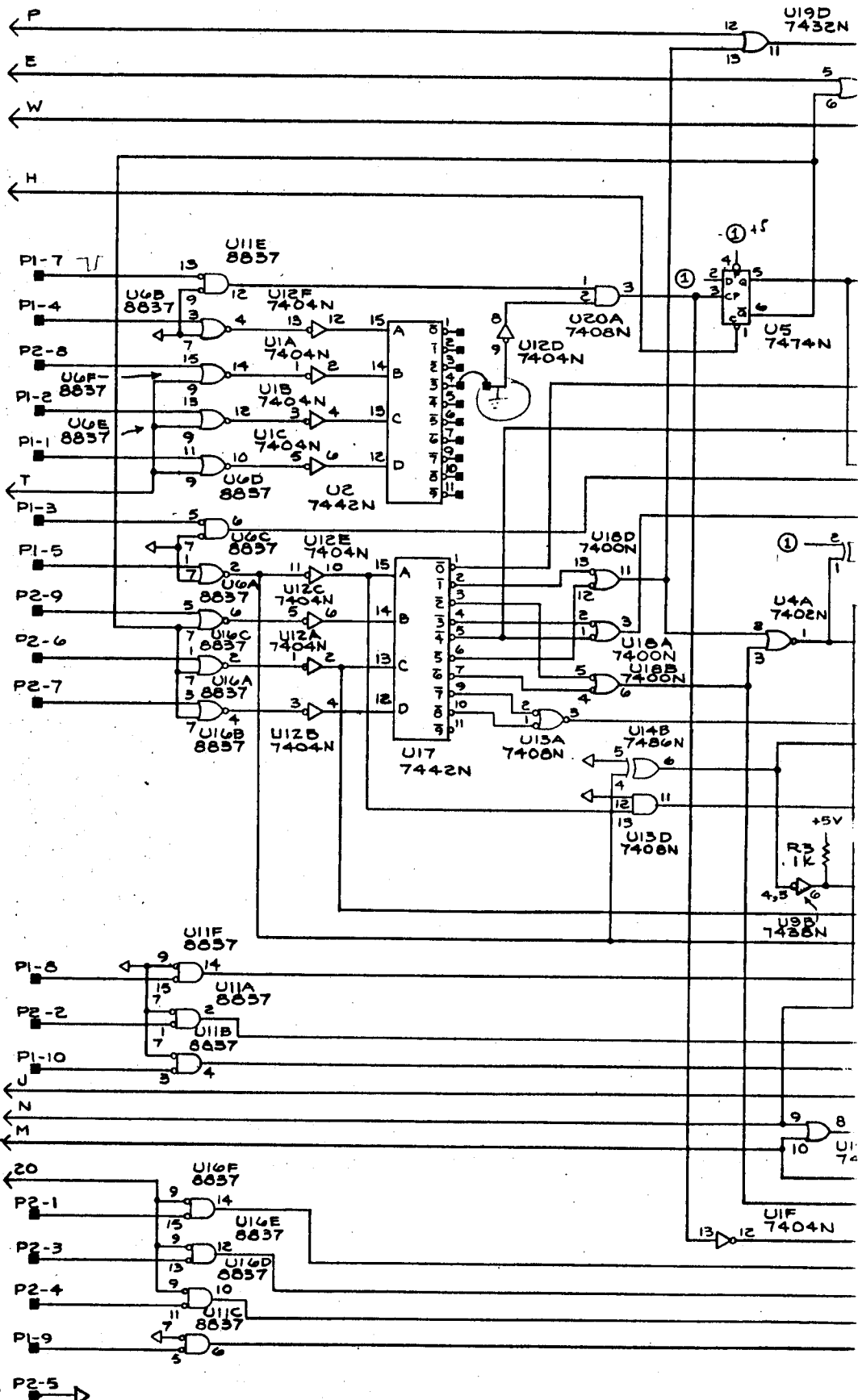
- clock 1 ECP1
- Beginning of  
data word ESYNC
- clock 2 ECP2

- TO
- T1
- T2

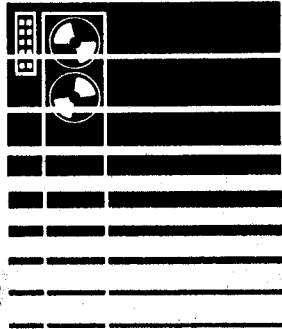
- 12 CALO

Data bus

Ground COM







# Computer Manufacturers

ECPI  
ECPI  
ECPI  
DW  
AVI

VD1.5

DE01.5

FXTP  
TC

4

4661 BCD I/F

Page 6-13

## Chronology

Put device address on line in TD1-8

Put  $\overline{AVS}$  strobe out

wait for TC address ack

Monitor  $\overline{FXTP}$  platter busy line, ok when low

send  $\overline{ETWC}$  for one  $\overline{ECPI}$  clock cycle

pull down on DW data word line and start

reading BCD chars one per  $\overline{ECPI}$  cycle

$\overline{ECPI}$  will ack them in.

16 chars are required. DW must be low during r/w.